The FOUNDRY
August 1917
CLEVELAND, OHIO.
Vol. 45, No 8 Whole No. 300

Casting Chilled Car Wheels in a Canadian Foundry

The Methods Employed by the Canadian Pacific Railway Co. to Insure Sound Wheels Conforming to Unusually Exacting Specifications

By C E Gray

MANUFACTURING cast iron car wheels having chilled treads and soft hubs and plates is attended with difficulties not encountered in ordinary foundry work. If the outer part of the wheel is subjected to an unusually high chill to give it the qualities necessary to withstand extremely severe climatic and service conditions, the problem presented to the foundryman is further complicated. This is true of the work in the wheel foundry of the Angus shops of the Canadian Pacific Railway Co., at Montreal, where practically all of the cast wheels used on that system are made.

Owing to the severe winters in the territory traversed by the lines of the Canadian Pacific, the wheels must conform to specifications that are more exacting in many ways than those controlling the manufacture of wheels for many other roads. In order to avoid shelled spots on the tread, the depth of the chill required in the specifications is unusually high. The requirements for the three standard sizes of wheels, including the maximum and minimum allowable depth of pure white iron in inches are as follows:

Normal weight of wheel pounds.	Depth of pure white iron, minimum inches.	Depth of pure white iron, maximum inches.
625	½	1
675	9/16	1 1/16
725	5/8	1 1/8

It has been found that in order to produce this chill the iron must contain approximately 0.67 per cent silicon, 0.478 per cent manganese, 0.145 per cent sulphur, and 0.287 per cent phosphorus. Pig iron from five to six different cars is used in each mixture to insure uniform results and to avoid any discrepancy in the anal-

FIG. 1—VIEW OF MOLDING FLOOR IN WHEEL FOUNDRY OF CANADIAN PACIFIC RAILWAY CO

CANADIAN PACIFIC RAILWAY COMPANY
ANGUS SHOPS Montreal, December 5th 1911
Bed Charge MIXTURE FOR CUPOLA Wheel CASTINGS 3, 4, 5 & 6

CAR NUMBER	BRAND	POUNDS PER CHARGE	PER CENT	% SILICON	POUNDS OF SILICON	% MANGANESE	POUNDS OF MANGANESE	% SULPHUR	POUNDS OF SULPHUR	% PHOSPHORUS	POUNDS OF PHOSPHORUS	COST 100 LBS	TOTAL COST
	Midland	450		1.56	7.03	.57	2.56	.040	.180	.092	.41		
	Desoronto	700		1.40	18.70	.53	9.01	.017	.289	.170	2.89		
	Old Wheels	4750		.60	28.50	.60	23.70	.180	9.550	.400	19.00		
	Malleable Scrap	100		.66	.65	.30	.30	.10	.100	.20	.20		
	Steel "	400		.10	.40	.50	2.00	.10	.40	.10	.40		
	Manganese	20				2.00	.400						
	TOTAL POUNDS	7420			55.25		53.57		9.519		22.90		
	Gross Per Centage			.745		.722		.074		.308			
	Loss by Oxidation (Estimated)			20%		30%		03 Fuel					
	Net Per Centage (Estimated)			.596		.505		.104		.308			
	Net Per Centage (by Analysis)												

CH

FIG. 2—TYPICAL BED CHARGE FOR CASTING IRON FOR CAR WHEELS

ysis. When charging, great care is taken to place the iron in the cupola so that each charge will enter the melting zone with the greatest uniformity and at as great a distance from the tuyeres as possible. About 3,720 pounds of coke is used in the bed charge.

The first charge of iron is 8,000 pounds and the subsequent regular charges are composed of 925 pounds of coke and 8,800 pounds of iron. Figs. 2 and 3 are reproductions of the standard form on which the materials charged are recorded. It will be noted that the bed charge has lower silicon than the regular charges because there is less oxidation at the beginning of the heat and the impurities of the first charge do not vary appreciably. The wheels cast from the first iron usually tape 2 or 3. In Fig. 3, the percentage of wheel scrap in the regular charge is given as 53.42. Soon after this particular charge was made up the Canadian Pacific secured a large number of cars and wheels from outside manufacturers and consequently the supply of scrap wheels became greater than the demand. A scheme for utilizing this excess of scrap was devised by working out an analysis which reduced the steel and malleable scrap in the charge and increased the percentage of the scrap-wheel iron to 75. This mixture conformed to specifications and did not materially increase the foundry loss. The sulphur content is higher than in many makes of wheels, but service tests have proved that this has no detrimental effect providing the remainder of the mixture is properly made. The following mixtures, based upon analyses allowing for a high percentage of wheel scrap, have proved satisfactory:

Pig iron.	Wheels.	Malleable.	Steel.	Total.
1,700	6,200	500	370	8,770
1,500	5,600	465	350	7,915
3,400	4,100	700	600	8,800
2,500	5,200	450	650	8,800
1,200	6,700	450	450	8,800

The record of the tapping of the cupolas and the distribution of the metal is kept on a tap card similar to that reproduced in Fig. 5. The letters in the first column refer to the taps taken from the cupolas during the day. The figures in the second and third columns represent in inches the depth of the chill on test pieces cast from metal taken from the bull ladle and from the distributing ladles after the metal has been treated. The columns under "Floor Numbers" show the distribution of the metal to the various molding floors. By referring to the key at the bottom of the card, and remembering that the numbers less than 10

CANADIAN PACIFIC RAILWAY
ANGUS WHEEL FOUNDRY
WHEEL RECORD LBS. 875. MONTREAL 19..

WHEEL	NOS.	TAP LETTER	TAPE SIZE	WHEEL	NOS.	TAP LETTER	TAPE SIZE
DA 522	0	A	3				
	1						
522	2	G	2				
	3						
	4						
	5						
	6						
	7						
	8						
	9						
	0						
	1						
	2						
	3						
	4						
	5						
	6						

FIG. 4—WHEEL RECORD FROM WHICH TEST WHEELS ARE SELECTED

are not in code, it is easy to trace the pouring of the metal from each tap. The dashes and crosses appearing above the numbers indicate the amount of silicon or steel punchings added to the mixture, and are explained in the key at the bottom of the card. The number of pounds of manganese and silicon added to the metal in the large or small ladles is shown in the last few columns of the card. It is estimated that about 10 pounds of silicon and five pounds of manganese must be added to the metal in the large ladle to change the depth of the chill 0.10 inch. Additions in the small ladle are made in ¼-pound packages and the steel is added from a measure containing two pounds.

The melting equipment of the foundry consists of two 72-inch Whiting cupolas. Each of these is tapped into an eight-ton mixing ladle operated by an electric motor. The metal

CANADIAN PACIFIC RAILWAY COMPANY
ANGUS SHOPS Montreal, December 2nd 191..
MIXTURE FOR CUPOLA Wheel CASTINGS 3, 4, 5 & 6

CAR NUMBER	BRAND	POUNDS PER CHARGE	PER CENT	% SILICON	POUNDS OF SILICON	% MANGANESE	POUNDS OF MANGANESE	% SULPHUR	POUNDS OF SULPHUR	% PHOSPHORUS	POUNDS OF PHOSPHORUS	COST 100 LBS	TOTAL COST
	Midland	500	5.68	1.84	9.20	.97	4.85	.05	.25	.10	.50		
	"	500	5.68	1.10	5.50	.58	2.90	.04	.20	.09	.45		
	"	400	4.54	1.92	7.68	.78	3.12	.04	.16	.09	.36		
	"	600	6.82	1.40	8.40	.85	2.10	.04	.24	.09	.54		
	Desoronto	450	5.11	.68	3.06	.54	2.43	.02	.09	.17	.76		
	"	650	7.39	1.24	8.05	.55	3.58	.02	.13	.18	1.17		
	Old Wheels	4700	53.42	.60	28.20	.50	23.50	.18	8.46	.40	18.80		
	Malleable Scrap	400	4.54	.65	2.60	.30	1.20	.10	.40	.20	.80		
	Steel "	600	6.82	.10	.60	.50	3.00	.10	.60	.10	.60		
	Manganese	16				80.00	12.80						
	TOTAL POUNDS	8816	100.00		73.89		59.48		10.53		23.98		
	Gross Per Centage			.832		.674		.119		.272			
	Loss by Oxidation (Estimated)			20%		30%	Fuel	.030					
	Net Per Centage (Estimated)			.665		.471		.149		.272			
	Net Per Centage (by Analysis)												

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FIG. 3—TYPICAL CHARGE FOR CUPOLA MELTING WHEEL IRON

is poured from these large ladles into distributing ladles carried on trucks which are moved along a narrow gage track by means of an endless cable passing over an electrically driven drum. These small distributing ladles, which have a capacity of about 950 pounds, are then lifted from the trucks by hoists which traverse the molding floors and carry the metal to the molds. The apparatus for handling the metal is shown in Fig. 1. The two mixing ladles and the track for the ladle train are shown at the right of the illustration. The cables suspended over the molding floors control the operation of the hoists, one line of each pair controlling the horizontal movement of the hoist, and the other the raising and lowering of the burden.

Method of Pouring

As shown on the tap card, Fig. 5, about 15 wheels are poured from each tap. The amount of metal run into the mixing ladle at the beginning of each heat is gaged so that each subsequent tap from the cupola will be sufficient for pouring approximately 20 wheels. Some of this first metal is poured into a 50-pound test ladle and from this a chill test piece 1½ inches wide, 2 inches thick and 6 inches long is cast. This piece is solid enough to break by the time the tenth wheel has been poured. From observation of former test pieces the foreman or his assistant is able to judge whether the iron is soft or hard. The metal to be used for the remaining five wheels from this tap is treated with manganese, titanium or silicon to bring about the desired degree of hardness. The fifteenth small ladle is held until another test piece from the mixing ladle has been examined. This piece is solid enough to indicate the character of the iron for the next tenth wheel. The metal for the first 10 wheels of the next tap is treated according to the character of a test piece poured from the fifth small ladle of the preceding tap. This iron had previously been treated to correct faults discovered in a test piece taken from metal in the bull ladle.

A definite system of pouring the wheels on each molding floor is followed. Metal from the first tap is served to the molds at one end of the foundry on one day, and on the following day it is poured at the opposite ends of the molding floors. Five distributing ladles are filled from the bull ladle, and are carried on the ladle train to the heads of five molding floors, where they are lifted by hoists traveling on overhead runways over the molding floors. These hoists carry the iron to the desired molds, where it is poured. The ladles return to the bull ladle, and on the next two trips of the train 10 wheels in the same five molding floors are poured. The metal from the next tap is served to molds in five different molding floors. The distribution of the metal from each tap is clearly indicated in Fig. 5.

After a molder has poured five wheels he is permitted to shake out the flasks. The castings are cleaned as much as possible by scraping and hammering, and are moved to the ends of the molding floors for further cleaning. The gates and sprues are knocked off and the center cores removed, after which they are placed on a hot-wheel train and carried to the annealing pits.

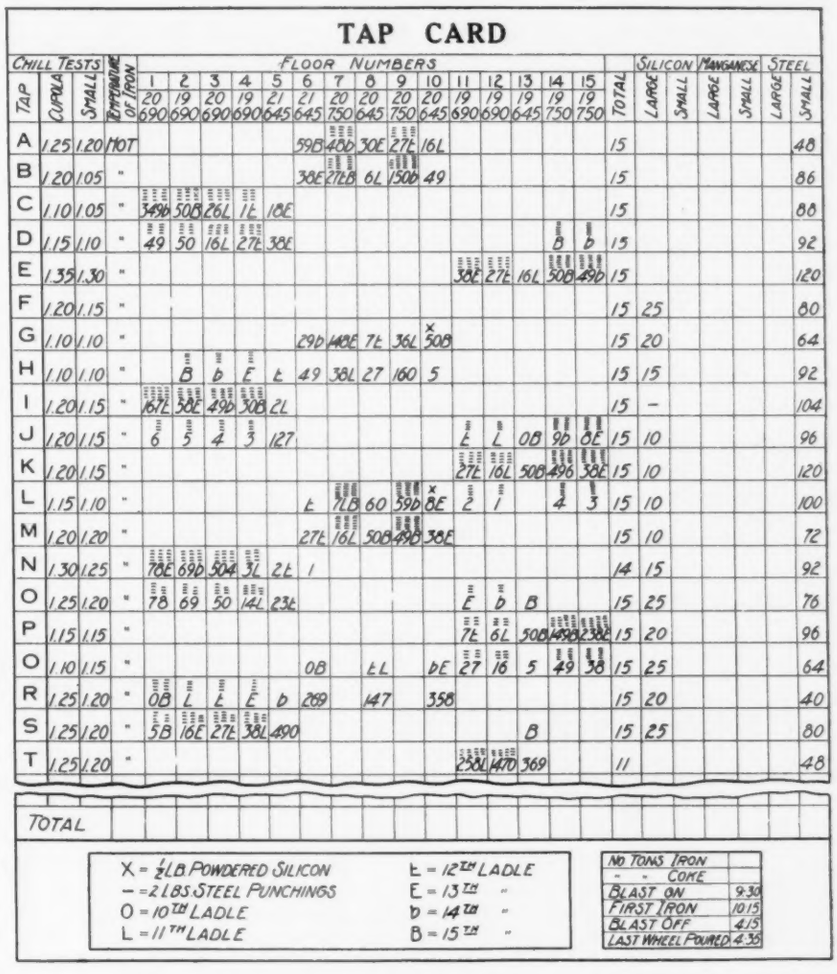


FIG. 5—TAP CARD SHOWING DISTRIBUTION OF METAL AND LADLE TREATMENT

The 64 annealing pits are arranged in four rows of 11 and two rows of 10. Each pit, with the exception of two experimental ones, is lined with fire brick and has a capacity of 25 wheels. On account of the depth of these pits and because the foundations are on hard clay, it has been necessary to connect up each pit with a 7-inch pipe to provide ventilation.

An overhead traveling crane equipped with two hoists spaced 4 feet 6 inches apart to conform with the distance between center lines of the rows of pits, is used to handle the hot wheels. The crane hooks are equipped with ingenious tongs which grip the walls of the bore of the wheel. When the wheel is lowered into the pit, the weight of the tongs after the load is taken off is sufficient to cause them to fold up, thereby releasing the grip on the wheel. The points of the tongs which come in contact with the wheel bore are forged with angular teeth to prevent slipping.

How Internal Stresses are Discovered

The wheels are left in the annealing pits for four days, and after they are removed from the pits they are allowed to stand over night to allow them to cool sufficiently for the final operation which cleans the wheels.

The purpose of the annealing is to reduce the strains set up in the plates by the chilling of the treads. A thermal test has been established to check the annealing operations and to insure the elimination of stresses in the plates. The test consists of pouring a band of metal 1½ inches thick and 4 inches deep around a cold wheel. If the wheel cracks across the tread or through the plate in less than two minutes, the wheel, and all others from the same mixture of metal, are rejected.

The effect of the annealing process depends upon the temperature of the pits and the time the wheels are subjected to the heat. A small test bar placed in one of the pits for only six hours will show a white fracture when broken, but will be so soft that it can easily be cut with a lathe tool. As a matter of fact, the temperature of the annealing pits is maintained at about 1,700 degrees Fahr. After three or four hours the temperature falls 300 or 400 degrees, but on account of the heavy cross-section of the wheel tread, no noticeable softening occurs. The Roberts-Austens diagram shows that when 1,292 degrees Fahr. has been reached, there is no softening because the martensite and cementite, the hardening elements, are then stable.

Tests made on annealed and unannealed wheels under a drop testing machine showed that 35 per cent more blows are required to break annealed wheels than are necessary to break unannealed ones. The test wheels are selected from a wheel record similar to that shown in Fig. 4. This shows the consecutive numbers of the wheels together with the tap letters and the tape sizes. The inspector selects two wheels indicating the greatest shrinkage (smallest tape size) and having the least weight. One is used for the thermal test and the other for the drop test. Another wheel having the greatest tape size and weight is broken and inspected for the depth of chill. The results of these tests are recorded on a daily summary sheet, and in nearly every case, each failure can be traced to a definite cause. Fig. 6 is a reproduction of the daily report of wheel failures made by the inspector. It will be noted that the defects caused by poor molding are charged to the molder who performed the poor work, and that failures due to circumstances beyond the control of the molders are charged to company loss.

This record has proved of great benefit in producing better wheels and eliminating carelessness among the molders. A further check upon the performance of the wheels is maintained by a strict account of all failures in service, and a record of the mileage made by each wheel. By assembling the information contained in these reports it has been possible to work out the percentage of shelled spots, flats, broken flanges, cracked plates, etc., for each size and type of wheel. These statistics have been an important factor in the development of better methods in the wheel foundry.

The broken flange problem has been receiving considerable attention during the last few years, because it is believed that many derailments have been caused by defects of this kind. The heating of the wheel due to the application of the brakes and the cooling of the flange in snow may be a contributing factor to flange failures, but the tendency to increase the weight of the cars without adequately increasing the weight and strength of the wheels has been one of the most important causes.

In an endeavor to remedy trouble of this kind the Canadian Pacific designed an 880-pound wheel having a strengthened flange which would just clear the frogs. The cross-section of the tread was so large that sufficient chill was not produced with the standard mixture and it was found that if the analysis were changed to suit this condition, the Master Car Builders' regulations would be violated. To overcome this difficulty, nickel-chrome pig iron was used, the mixture containing 0.98 per cent silicon, 0.81 per cent manganese, 0.02 per cent sulphur, 0.05 per cent phosphorus, 0.98 per cent nickel and 2.40 per cent chrome. It was determined that in this combination there would be no loss in the nickel and about 2 per cent in the chrome. When an excessive chill was indicated by the test piece, titanium was added with

CANADIAN PACIFIC RAILWAY

TESTING DEPARTMENT, ANGUS SHOPS.

BAD WHEEL REPORT Date October 28th 191

Date Cast October 21 191
Date Insp'd " 28 191

Floor No.	MOULDER	HELPER	Sand in Plate	Blow	Break Down	Broken Cores	Chill Crack	Chipped Run	Chipped Flange	Closed Up	Cracked Hub	Cracked Plate	Crushed Core Eye	Crushed Flange	Cut Centre Core	Dross	Flange Crack	Hollow Hub	Hollow Rim	Iron Bough	Loose Clamps	Pitted Throat	Pop	Run Out	Sand in Brackets	Sand in Flange	Sand in Hub	Slag in Plate	Sand in Rim	Tread Rough	Scab	Shaken out too Hot	Shelled Flange	Sweat	Swollen Flange	Swollen Rim	Thin Plate	Thin Flange	Uneven Flange	Warped	Washed Pocket	Wash Out	Wrinkled Chill	Members—Bad	Company Loss	Members—Good
1	Kovar	Pastrampka																																								0		20	
2	Rahemy	Kato			1																																				1		19	
3	Comeau	Capowick																																								0		20	
4	D'Heureux	Drauva					1																																			1		19	
5	Dupre	Bovenzski																									1															1	1	19	
6	Dupre	Tomnik																																								0		20	
7	Bertrand	Radoski					2																																			2	1	18	
8	Gobeyn	Jarechuski																																								0		20	
9	Demarais	Stipyn	1																																							1		19	
10	Antonik	Jacoban																									1													2		3	1	17	
11	Dorion	Gyndjian				2																					1															3		17	
12	Smit	Kosmoski																																								0		20	
13	Bitzz	Elliott			1	1	2																																			4		16	
14	Shelton	Hosimoto					1																																			1		19	
15	Beland	Sidor			1	1																																			2	1	18	
		TOTAL	1		3	4	6																				3													2		19	4	281	

Wheel Inspector.

FIG. 6—REPORT OF TEST DEPARTMENT ASSIGNING CAUSES OF DEFECTIVE WHEELS

good results. The wheels made from this nickel-chrome mixture were placed in service under locomotive tenders where they would be subjected to about 30 per cent heavier brake pressure than under a coal car, and would have a mileage exceeding that of wheels under a coal car by at least 300 per cent. The results of these service tests showed that the wheels compared favorably with other satisfactory types of wheels then in use, but for various reasons they were not adopted.

This experiment showed that nickel and chrome have an important influence of the crystallization of the iron and on the tendency for the thread to shell out. This was indicated by the fact that it was necessary to reduce the percentage of steel and scrap to secure the desired carbon content. The mixture was composed of 22.46 per cent pig iron, 6.25 per cent steel, 50.8 per cent scrap wheels, 6.93 per cent Mayari (nickel-chrome) pig iron and 6.25 per cent malleable iron.

The Influence of Design on the Cost of Patterns

By M. E. Duggan

The article in the January issue of *The Foundry* by John Leafstrom is interesting and instructive. He shows in a clear, practical manner how a machine detail which, if handled in a careless manner becomes complicated and costly, may be made simple and inexpensive by means of an ample knowledge of patternmaking and molding practice.

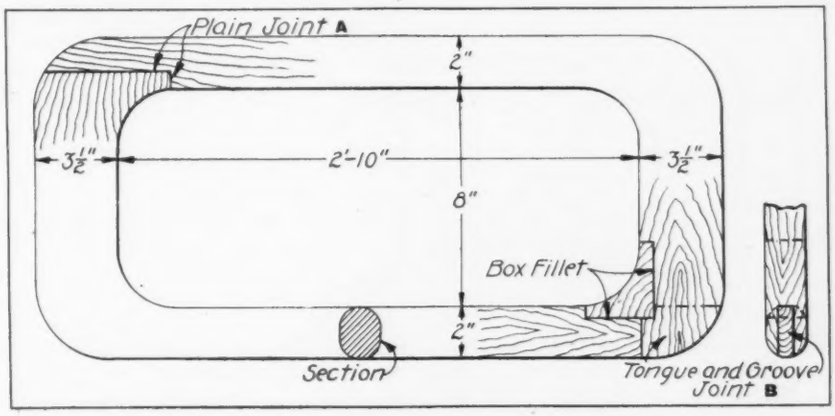
What effort is being made to insure the foundries of today against the embarrassment caused by improperly made patterns? Frequently complaints are heard that machine parts are so complicated in their design that the patternmaker is at his wits end to know how to construct a pattern which will be practical to mold and yet remain within a reasonable limit of cost. In the pattern shop, foundry and machine shop improved methods are being studied and worked out every day, but in too many cases, this progressive study is being made without a sufficient amount of co-operation between the three departments. The foundryman, when impressed with the advantages of co-operation, is dubious as to the results obtained. Perhaps co-operation between the patternmaker and the foundryman has meant little to him. In too many cases, the draftsman has attempted to carry out his ideas of co-operation in a clean and comfortable office rather than in the foundry. This has led the men in the foundry to underestimate the practical value of the draftsmen's opinion. They feel that his information is drawn from other men in the office whose ideas are not gained from actual contact with founding problems.

The draftsman who watches the process of molding unusual or exceptional castings in the foundry not only discovers facts of value to himself but also impresses the foundrymen with the fact that he is interested in their problems. This leads to an appreciation of his efforts which is a long step toward co-operation. The draftsman who makes a practice of frequently visiting the molding floor will soon break down the prevailing opinion among molders that many of the shirt-sleeved office draftsmen spend their time over drafting boards utilizing two or three days for fancy drawings to illustrate patterns which could be clearly sketched for all practical purposes in a few hours' time.

The cost of a pattern in many instances can be attributed to the lack of mechanical judgment displayed by the patternmaker. An example of an inexcusable waste of time and money is indicated in the accompanying illustration, which shows a pattern for one of two steel castings ordered from a certain foundry. The shape and dimensions were the same in both castings except that one was slightly longer than the other. This difficulty necessitated the making of two patterns. Owing to the large amount of work in the pattern shop of this foundry one pattern was sent to a jobbing pattern shop, the other being made in the company's shop.

The patternmakers in the foundry pattern shop cut and fastened the parts of the pattern as shown in the accompanying illustration at *A*. The joint was easily and quickly made at a minimum cost. The pattern thus constructed was satisfactory in every respect and could have been used for from one to 25 castings. The parts made in the jobbing shop were jointed as shown at *B*. The end pieces were grooved and the side pieces were tongued to form a joint and the inside radius at the corner was formed by a box fillet. On account of the extra labor involved in making this fancy joint the pattern was not delivered on time and the making of the casting was delayed 24 hours.

This example is not presented as a criticism of the method employed by the jobbing pattern shop. The case however, indicates how easily the lack of judgment and co-operation may result in making patterns unnecessarily expensive. The patternmaker who can construct his patterns simply and yet make them strong enough to meet the demands of molding, is really promoting the spirit of co-operation for which all foundrymen, patternmakers and machine shop foremen are so eagerly striving at the present time.



INEXPENSIVE AND EXPENSIVE METHODS OF JOINING PIECES OF A SIMPLE PATTERN

Electric Resistance Alloy

All alloys for electric resistance elements containing substantial quantities of nickel and chromium are covered by what is known as the Marsh patent, No. 811,859, issued Feb. 6, 1906, and which was sustained in a recent suit. The Marsh alloy contains approximately 80 per cent nickel and 20 per cent chromium, or 80 per cent nickel, 18 per cent chromium, and 2 per cent aluminum. Alloys consisting of iron, 70 per cent, and nickel, 30 per cent; iron, 80 per cent; nickel, 15 per cent, and manganese, 5 per cent, have a life of only one two-hundredth of the Marsh alloy when used as resistance elements.

When 10.68 per cent chromium is added to 89.32 per cent nickel, the melting point of the latter is reduced 15 degrees Cent. Twenty per cent chromium reduces the melting point of nickel 30 degrees Cent.

The Use of Chills in Producing Sound Castings

How to Control the Action of Cast Iron, Malleable Iron or Cast Steel as It Passes From the Liquid to the Solid State

FOUNDRYMEN are beginning to realize that too little attention has been paid in the past to a study of the behavior of metal as it cools in the mold. The gating of castings, the use of chills, and the methods of pouring employed have been the results of experience in which the effects of rough experiments have been the deciding factors as to what is good or bad practice. As a rule, foundrymen have considered their investigations completed as soon as they hit upon a plan of gating and pouring which produces satisfactory castings. When a different type of pattern comes into a shop, the experimental work must be repeated in all its details.

During the past decade, a number of foundrymen have delved into the subject of controlling the action of cooling metal with unusual thoroughness. The results of the investigations of these men have been given to the foundry industry through the medium of trade journals and papers read at the meetings of foundrymen's associations. The latest discussion of the subject took place at the December meeting of the Birmingham branch of the British Foundrymen's Association. The subject, "The Functions of Feeders and Denseners," was introduced by papers dealing with the use of chills in cast iron, malleable iron and cast steel practice. Abstracts from these papers follow:

Control of Cooling Metal in Cast Iron Work

By J J Howell

IN a paper read before the November, 1916, meeting of the Birmingham branch of the British Foundrymen's association, J. E. Fletcher assumed that feeding is necessary to facilitate the escape of occluded gases in the molten metal. The writer believes that if the gases follow a known law and converge to the center towards the mother liquor, feeding with a rod would help the gases to escape. However, if Mr. Fletcher means to convey that gases are the sole cause of cavities, and that if the gases are eliminated from the metal, the cavities will not occur, it is believed Mr. Fletcher is wrong. With or without gases, feeding is necessary for the production of sound castings of great bulk. Cavities are formed in castings by occluded gases, and there are also shrinkage cavities due to the presence of an impoverished mother liquor. This can only be rectified by keeping in touch with the mother liquor and feeding into it new iron that will supply it with the necessary material for building up a tight crystalline mass.

Why Feeding is Necessary

To understand why feeding is necessary, and how to feed properly, it is imperative that we should have some knowledge of the changes which take place in cast iron when passing from the liquid to the solid state. If cast iron, after being poured into the mold solidifies without any change taking place, feeding will not be necessary, for it is an accepted fact that cast iron in the molten state is a homogeneous mass with all its constituents in solution, and if quenched in that condition, becomes a hard, white, crystalline mass. Under commercial conditions, cast iron is rarely cooled as quickly as this; therefore the elements are not trapped in solution, but time is allowed for them to separate out. Let us imagine that a large mold has just been poured. The metal in the mold may be considered a saturated solution of carbon, silicon, sulphur, phosphorus and manganese in iron. Cooling commences at once, all faces of the mold and cores acting as cooling surfaces. The liquid iron gives off heat waves which are conducted away by the cooling surfaces. The crystals that first freeze out are carried along with the heat waves, and arrange themselves at right angles to the cooling surfaces. The primary crystals are richer in iron than the crystals that immediately follow, and if the first crystals carry pure iron, the molten iron left behind becomes richer in impurities. As the temperature falls, other crystals freeze out, taking with them a big percentage of the iron left. If this process is repeated for some time, the iron which remains in the molten state for the longest period, termed the mother liquor, will become a concentrated mass of impurities. This is where feeding plays its part and if new, clean metal is fed to the impoverished mother liquor, from time to time, it can meet all the demands made upon it by the progressive crystal formation. If this operation is not properly performed, the impoverished mother liquor is unable to supply sufficient crystals to give a solid compact mass. The result is either a large cavity, or a series of small ones, or a loosely packed mass of large crystals giving a very weak casting.

The feeding of large and bulky castings is of great importance, for the great length of time taken in cooling down means a longer period for crystal growth, and incidentally, a weaker casting. Professor Turner has said that the strength of a large casting per unit of area is somewhat less than that of a small one, since the closeness of grain is usually, though not always, associated with increased tenacity. Shop practice proves this to be true; there is a density or hardness that gives the best results. The greatest strength is associated with small crystals which have not arrived at the brittle stage, and it is up to foundrymen to determine the proper degree of density for their own particular work. Having determined the density, they should be sure that they do not upset it by improper feeding.

Design Must Eliminate Sharp Angles

An aspect that should be considered in the production of castings is that of design. The draftsman should know that if anything happens during the cooling to affect the growth of the crystals, or to cause them to take a contrary direction, such action gives rise to a plane of weakness and that, therefore, it is very important, in large castings where strength is required, that there be no sharp or recurring angles, as these must

certainly lead to planes of great weakness. The greater mass of metal in such corners is the last to cool, and the crystals which form at right angles to the cooling surface are disturbed by butting up to each other, resulting in a plane of weakness.

It often happens that castings which pass all the mechanical tests satisfactorily fail when subjected to steam or water pressure. Such failures are invariably caused by faulty crystalline formation which might have been avoided by properly designing the casting. It is of vital importance that designers understand the feeding problem, so that all lines which adversely affect the crystal flow can be eliminated. Irregularity in design should also be avoided as far as possible, for it is obvious that the thinner metal is the first to cool and draws on the reserve of the molten section, with the result that either a fracture must occur or the heavier section will be a spongy and segregated mass unless specially treated.

Problems Facing Foundrymen

However, the designer is not able to remove all the ills that beset foundrymen. Local heavy sections, thin walls joining up to strong ones, and heavy bosses placed in impossible positions to feed are conditions the foundrymen must face. In such cases the careful application of chills or denseners is of value. The changes which take place during the cooling of cast iron are not instantaneous; they are chemical changes and require an appreciable time to accomplish. The chill is thus allowed to have a marked effect, a chill applied to a heavy section being a much better conductor of heat than the sand of the mold. It carries away the heat from the thick part of the casting much faster than the sand from the thinner section, thereby giving a more uniform growth. Assuming that the metal used is suitable for the work in hand, the whole question of perfect crystallization resolves itself into the rate of cooling.

Parts of Castings Not Uniform

F. J. Cook, in a paper recently published, says it is a well-known fact to metallurgists and foundrymen that the physical properties of most cast metals, such as the size of crystals, hardness, coarseness of grain, strength, etc., are greatly influenced by the rate of cooling from the molten to the solid state, and in none is this more freely shown than with cast iron; in fact with this metal it must only be considered second to, and in some cases of equal importance to the chemical composition of the metal itself, when considering it on the lines of its tensile strength. To prove this statement by ocular demonstration, Mr. Cook had a bar cast in the shape of a wedge, tapering from ¼ x 3 inches at one end to 6 inches square at the other and being 2 feet long. This was cast in a dry sand mold from metal fairly low in silicon and total carbon, such as would give strong castings of 1¼ to 2 inches thick. It was cast on end with the thin end down and was left in the mold until properly cooled. When the bar was broken, the fracture ranged from close-grained white iron at the thin end, to open grain with large crystals in the center, and metal of very little cohesion at the large end. To demonstrate further the difference in various parts of the bar, hardness tests were taken at 5 inches from the thin end, 3 inches from the thick end, and halfway between. This hardness was taken by the drill method, the results being 70, 56 and 40, respectively. The differences in hardness and fracture show what is likely to happen in the various castings mentioned if they were all cast from the same metal. It is also possible for the differences to occur in the same casting, if badly designed, with abnormally thick and thin parts.

If a section similar to that used in Mr. Cook's experiment occurs in a casting, it is obvious that a similar result will be obtained unless the casting is specially treated. Chilling is perhaps the easiest and least laborious method of doing this. Care must be exercised to see that the chill is not thick enough to cause a chilled surface on the casting, but just thick enough to densify the crystal formation, to give a good wearing surface which is not too hard for machining operations.

Preparation of Chills

In preparing chills for a flat surface, a pattern may readily be cut to the desired length, width and thickness. If the surface is an irregular one, expense of a complicated pattern can be saved by pressing a piece of pliable clay on the pattern till a good impression had been obtained. The clay can then be cut to the thickness required and left on the pattern all night to stiffen. A good pattern for the chill may be obtained in this manner. When molding these chills it is good practice to cast a couple of sprigs in the back, or a rod, according to the weight. These assist in securing the chills safely in the mold. If the chills are to be used on the outside of the mold, they should be placed on the pattern and rammed up in the usual way, but if they are to be used in cores, the molder should be sure that clearances have been allowed so that the chill and the core iron do not butt together, thereby hindering the normal contraction.

Use of Chills in Malleable Iron Practice

By A Fraser

IN using chills in malleable work, the main points to be remembered are that this iron has a very high liquid shrinkage and a narrow range of fluidity varying considerably with the composition. It also has high linear contraction which varies slightly with the composition, as the castings should be of white iron throughout if success is to be attained after heat treatment. Those three features in the cooling of malleable iron present difficult problems which may be most easily solved by the judicious use of chills. Although these devices have many uses, one of their chief functions is to eliminate the local liquid shrinkage cavities which are usually found in the weighty sections of a casting, which take the form either of a hollow in the interior, or depression in its surface. This defect can be overcome by placing a gate or feeding head on the sections likely to be affected in this manner, but where there are a number of such places on the same casting, the molten metal and additional work required to procure a sound casting is excessive and does not lend itself to economical production. The service required from chills in a cast of this kind is to cool the sections on which they are placed so rapidly that all liquid shrinkage will take place before the metal in the gate and the parts of the casting connecting it with the heavy section has solidified.

When chills are used, care should be exercised to have them of the proper size and weight, because if the one nearest to the gate or feeding head is too large, it will check the flow of molten iron to the parts

beyond it and cause cavities or sponginess even in the thin sections. When a number of chills are used, those nearest the gate should not be so small that the flow of iron passing them can raise their temperature before the mold is filled, thus impairing their efficiency as heat conductors at the required time.

Another defect frequently found in malleable iron castings which often may be rectified by chilling, is called in foundry parlance a "sear". This is a hot crack resulting from linear contraction on adjacent sections cast at angles to one another while their junction is still in a semi-rigid state and has yet to attain sufficient cohesion to overcome the resistance of the mold to their passage. It usually occurred where the sections are at acute angles to one another and is found at the apex of the interior angle. In appearance it resembles a hair, varying in thickness, laid irregularly on the casting. Chills should not be used indiscriminately to rectify this fault as the addition of a radius to the pattern usually overcomes the difficulty, provided the radius does not result in such an accumulation of heat at that point that liquid shrinkage was encountered. Another use for chills is in the prevention of flying, or the breaking of castings during the later stages of their cooling, or while undergoing the annealing process. This common trouble is the result of the different rates of cooling and varying time of contraction in the different sections of the casting. The method commonly adopted to relieve the stresses causing such breakages is to transfer the casting while still at a high temperature into a muffle and cool very slowly. In case such treatment cannot be given, chills may be used to equalize the cooling. Castings may thus be produced successfully without slowly cooling them.

Protect Surface of Chills

A chill on which the metal impinges and becomes at once stationary should be coated only with a substance with a low volatile constituent; otherwise, with a thin-sectioned casting, blowholes or a depression will occur on the surface. A chill subjected to considerable heating before the mold is filled should be coated with a substance containing a much higher volatile constituent so that it is protected for some time by a film of gas. On a chill which is weighty enough to stand up to the work expected of it, a coating of black oxide of iron, formed by heating to a good red color, has been found to afford sufficient protection. With this coating the chill must not stand too long and collect moisture, as the red or hydrated oxide is, of course, abhorrent to molten iron. Iron which has a clean metallic surface should not be used for chills without previous coating because of the danger of cementation to the castings. Gray iron chills which become heated to redness should not be used many times, as, apart from their liability on repeated heatings to increase in volume and become distorted, small fissures containing gas may develop in the iron. With an increase of temperature this gas expands and is quite likely to cause very serious blowholes.

Chills must be placed so that their properties will produce the desired effect. All chills, if left standing for some time before casting in green sand or partially dried molds, collect moisture, and if free egress is not allowed a faulty casting is obtained. If a chill is placed with its face in a perpendicular position or at a gently rising angle, this trouble is almost eliminated, as the metal rising in the mold drives the vapors before it. Horizontally placed chills, either on the top or on the bottom of the casting, are not as trustworthy in their action, as vapor is frequently entrapped at the surfaces, especially in the case of those at the top of the mold.

Heading, Gating and Chilling Steel Castings

By A Fraser

FOUNDRY practice in steel casting plants has a number of features in common with the procedure of making castings in a malleable shop. There are, however, differences in detail which must be considered. Steel is cast at a high temperature, has a narrow range of fluidity and freezes rapidly. It also has a high linear contraction immediately after passing the pasty or semi-rigid state in conjunction with its lack of cohesion while in that state. The value of chills on steel castings is almost negligible excepting on thin-sectioned and small light castings. On this class of work their use is essential to economical production. The rapid freezing of the steel, however, imposes a short limit on the chill's effective time of action; therefore, to get the maximum effect in the short time at disposal, the chill must be considerably larger than if it has to produce the same effect on a malleable iron casting. The high casting temperature caused a liability to cementation of the casting and chill if the latter is not weighty or had any sharp projections.

Occasionally castings are required which need treatment with feeding heads or chills, but on which it is impossible to get feeders in the proper position or to apply external chills of sufficient weight to be effective. The method adopted to overcome this difficulty is to insert pieces of clean wrought iron into the sand of the mold, allowing them to project into the section where the cooling has to be accelerated. This is a practice which cannot be recommended, as, apart from the danger of non-cementation of the steel and wrought iron and weakening of the casting, the occluded gases in the pieces of wrought iron very frequently cause sponginess and blowholes in their locality.

One of the most useful functions of chills in relation to the casting of steel is in reducing the frequency of hot cracks. The immediate cause of these cracks, which are common in even small castings, is the resistance of the mold, at its angles and projections, to the inward movements of the different parts of the casting. The cracks occur at the weakest part of the casting in the locality where the tension exists. Those weak places are usually found where there is an accumulation of heat or where the thickness of the section is increased. Easing the resistance of the mold to obviate this fault is no doubt the best method in castings of large size and weight. Also, the casting of connection or tie bars is good, although it increases the consumption of metal and adds to the finishing costs. Where large numbers of castings are cast in a few minutes, and the crack occurs a few seconds after pouring, the first method is impossible, and the second is not economical when the castings are light. The chill appears to be the best remedy in a case of this nature. It need not be as large as if intended to meet liquid shrinkage, as it is doing effective work until the steel in contact is at the close of the semi-rigid state.

The feeding head is an essential feature on all heavy steel castings, and in nothing does the skill and experience of the foundryman show to greater advantage than in the comparative size of the head and the casting to which it is attached. The size of the head should be regulated by the design of the casting, the position of the pouring gate, the distance to which feeding action is required and the relative temperatures of the mold and head. The position of the pouring gate should be considered with the object of finding whether the entering metal will heat the mold so that a local slow cooling will ensue; also whether the stream of metal will flow over parts which naturally retain their heat longest, and thus further retard their cooling. To some degree, the height of the head is controlled by the range of feeding needed. Hydrostatic pressure is required to force the viscous steel into the last of the places where cavities are likely to be formed on cooling. To avoid abnormal height, the number of heads should be increased. It must be understood that with castings which have large surface areas as compared with their bulk, such as a 1-inch square bar, the range of feeding is very limited, even with a head of unreasonable height. If the mold proper is hot and the head mold cold at casting, the head should be comparatively large, because it has to supply fluid metal to a more slowly cooled casting. If the head mold is at a good temperature a much smaller head can be used. The shape of the head is probably the greatest factor in its efficiency; and a large surface area is its greatest enemy. Every effort should be made to keep it as compact as possible. A fairly deep rectangular form has been found to give excellent results.

Proper Method of Attaching Heads

Heads which are correct in size, form and all other essentials, often are made ineffective because they are improperly attached to the casting. The center of the body of the head should be as nearly as possible immediately over the inlet to the casting. The bottom of the head should also be as close to the casting as is compatible with a perfect mold. If those conditions are complied with the connection between the two is short and compact, and is kept open until the casting's demand for metal has been satisfied. If these two bodies of metal are kept further apart, a connection of much larger sectional area is required; otherwise strangulation takes place and the large head is rendered useless.

Varying Strength in Different Parts of a Large Casting

By W. J. Keep

Question:—We make large power presses, punch presses, gate shears, bulldozers, etc., in which very large sections are used. It has been our experience that it is impossible to prevent the cast iron in these large sections from becoming coarse grained and spongy, with occasional hollow places in the center. We use iron containing about 1.50c per cent silicon. We would like to know if tests have been made and published showing the strengh of cast iron in the various parts of a casting. It seems evident that the strength of the iron near the surface will be much greater than it will be in the center.

Answer:—In Volume XXV of the Transactions of the American Society

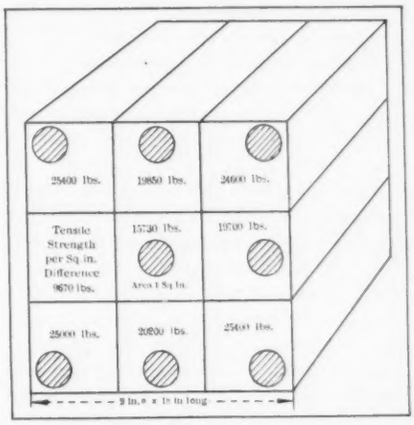


DIAGRAM OF STRENGTH OF CASTING

of Mechanical Engineers, page 884, the subject of varying strength in parts of the same casting is treated at considerable length. One experiment made at the plant of R. D. Wood & Co., is illustrated herewith. The large square represents the end of a block of cast iron, 9 inches square and 18 inches long. It analyzed as follows: Total carbon, 2.84 per cent; graphitic carbon, 0.60 per cent; combined carbon, 2.24 per cent; silicon, 1.10 per cent; phosphorus, 0.34 per cent; sulphur, 0.09 per cent, and manganese, 0.49 per cent.

This block was planed into nine parts and from eight of these were turned test bars of 1 square inch area. The tensile strength of each is given in the illustration. The corner is 9,670 pounds stronger than the center and the corner is 5,000 pounds stronger than the middle portion of the side. This is also shown by compression tests of ½-inch cubes taken at each ½-inch in depth from a 3½-inch square test bar. The center of the side is 2,810 pounds stronger than the center of the casting. It is upon this truss-like distribution of close grain that we depend for strength. The strongest portion of the test bar is its surface. If a hole were bored lengthwise through a test bar, it would not greatly decrease the strength of the bar.

In pouring castings of large section, a feeding head is provided and by churning and feeding liquid metal spongy spots are removed. Chills are placed on inaccessible parts to cause the metal to set as soon as that at the surface. The silicon and phosphorus are kept as low as possible so that the metal will set rapidly and all over at the same time. This also is done so the grain may not be coarse. If you wish a piece to appear of large section, cast it with a core, which would make it as strong a section as if cast solid. The pattern should be of the same thickness in every part and it is often necessary to uncover some part as soon as the iron is set so it will cool as fast as others. Keeping in mind a truss construction with every part the same thickness, you can make a sound casting as strong as you wish in every part and not obtain a coarse grain.

Production of Bauxite in 1916

The production of bauxite in 1916 was 425,359 long tons, which had a value of $2,297,825, an increase of 43 per cent in quantity and 52 per cent in value over 1915. Bauxite is the ore from which aluminum is smelted and the most notable increase in production for the whole United States was made in Georgia and Alabama. In 1915 the production of bauxite in these two states was 25,008 long tons, which was increased to 46,410 tons in 1916, a gain of 86 per cent. The production in Arkansas and Tennessee was increased from 272,033 long tons in 1915 to 378,949 long tons in 1916, a gain of 39 per cent. This increase can be attributed to the development of the well-known deposits in Arkansas.

A process for making uranium oxide has been patented by Charles L. Parsons, which consists of mixing thoroughly pulverized charcoal, sodium uranate or other alkaline uranate with fine-grained salt (NaCl) in the proportions of about 20 parts uranate, 1 part charcoal and 35 parts salt. Fusion of the mixture converts the uranate into oxide of uranium. The fusion is washed with a 3 per cent solution of sodium hydroxide and then with water. It is then digested with water and afterwards washed

with an acid solution, preferably a solution containing from 3 to 5 per cent of hydrochloric acid which removes the impurities. The oxide then is dried.

British Foundrymen's Association

The annual report of the British Foundrymen's association, presented at the fourteenth annual meeting in London on June 23 shows a total membership of 1021 against 965 last year. The council reported steady progress in spite of the war, the various branches having done excellent and valuable work for the foundry trade. Many interesting papers were presented and discussed, and visits to various works have been much appreciated by the members. The sum of $1750 was invested in war loans. Regret is expressed in the report at the death of Herbert Pilkington, M.I.C.E., M.I.M.E., the second president of the association. It is remarked that "Mr. Pilkington gave most valuable assistance from the beginning of the association and by his organizing ability made his mark on the work and conduct of the association".

With regard to the war, many members are serving their country and several have laid down their lives. "For those still at the front we wish a happy return at an early date, and for those who will never return we give out lasting gratitude," the official report reads.

A presentation in recognition of his former presidency was made to W. Mayer. J. Ellis delivered the presidential address. Apart from these items, the business was formal, the war preventing once more the more elaborate program customary in peace times. The progress of the association is encouraging.

Repairing Cracks in Steel Castings Electrically

By B W Bowers

THE process of welding cracks in steel castings electrically, has been a subject of considerable discussion among foundrymen, owing to difficulties resulting from improper methods of procedure. For the benefit of apprentices or beginners in this line of work, the following suggestions will prove of value.

It is common practice among many welding operators, to quickly weld a crack in a casting, with one application of the arc, using a higher amperage than necessary, disregarding the proper size and analysis of the filling-in material. The first problem to be considered is the amount of current applied to the casting, which in many cases is entirely too high. Many operators believe that with a large arc, 500 to 600 amperes, they can quickly melt, puddle and cover up a defect, without causing any chemical harm, when in reality, this excessive heat burns out the life of the metal, leaving the weld in a porous and brittle condition.

Cracks in castings should not be treated as shrinkage, but care should be exercised, and due consideration given to the expansion and contraction of the metal adjacent to the crack.

Completing the welding of a crack hastily and using only one application of the arc, are common causes for low efficiency and re-opening of these welds, as the heat, suddenly applied, intense and of limited duration, not only lacks sufficient time to distribute itself by radiation, but causes the welded metal to become brittle and lifeless, which fails in resisting the expansion, before subsequent cooling takes place, thereby opening the weld.

Next to be considered is the filling-in material, its size and analysis. Frequently, this is common wrought iron, or so-called welding wire, and it should not be used until its chemical composition is ascertained. Much of this welding iron contains a large amount of slag, and its carbon content is too high, causing weakness and hard spots in the weld. The best and purest Norway iron should be used, ranging in carbon from 0.07 to 0.10 per cent, the diameter depending upon the thickness of the metal to be welded and the depth of the defect. When using wire of small diameter, the flame of the arc practically burns the life out of the material before it enters the defect. When too heavy material is used, particles are burnt off and enter the weld faster than proper fusion can take place. It has been found that for the ordinary range of work, wire from ¼ to 5/16 inch in diameter, is best adapted.

Proper Method of Procedure

Considering that nearly every crack is of different length and depth, the first thought is whether it is wise and practical to repair it with the electric arc, or whether it should be condemned and cast over. Good judgment should be exercised in this respect and due consideration should be given to strength and safety.

A crack to be welded should first be burned or cut out V-shape, to its foundation, care being exercised not to cut away more of the original metal than possible. Burning it out with the arc is not considered good practice, as the sudden and excessive heat leaves a zone of oxidized metal adjacent to the weld, although in many foundries this custom is usually followed, owing to the difference in time and cost, compared with other methods of cutting.

Whenever possible, it is advisable to cut out a crack with a pneumatic tool, after which it should be slowly heated in either an oven or in a forge fire, the extent of heating depending upon the gravity of the defect and sufficient time should be allowed for the maximum expansion.

Small cracks of less importance need little or no preheating, as the temperature of the arc is sufficient.

After properly preheating, the welding should begin immediately. The current supply should range from 250 to 400 amperes, at voltages from 60 to 90, according to the size of the crack. A sharp carbon is highly essential for welding in order to concentrate the flame to a small point. The cable should be as flexible as possible, to permit of the free manipulation of the electrode. The crack should be slightly tilted, so that whatever slag forms will flow to the side of the arc. To eliminate the slag and bring it to the surface, always feed the filling-in material on the dark spot, directly underneath the point of the carbon. The bright or yellow spot is slag.

The material should be fed evenly and without haste. Speed does not produce good results.

A crack should never be welded with one application of the arc, but should be divided into three or four layers, according to its depth, allowing an interval of from two to five minutes between each layer. The first layer should be welded with the maximum amount of current, decreasing the voltage with the last layer, thus reducing the pressure. A reduction in amperes does not reduce the temperature, but reduces the volume. A riser, approximately ¼ inch in diameter, should be left upon finishing the weld, which usually contains the majority of impurities, and aids in retaining the heat.

New Cleveland Stove Foundry for Maximum Output

Fig. 1—Looking Toward the South End of the Foundry From the Shipping Office.

UNDER the impetus of the constant flow of orders during the last two years, building construction in the iron and steel industry is advancing with enormous strides. In percentage of new buildings erected, foundries have more than held their own. Maximum production is the goal which every foundryman is seeking and expense is a minor consideration if the output resulting from the expenditure comes up to expectations.

Foundrymen who are familiar with stove foundries know that in the past, scant attention was given to equipment the bare casting essentials being the rule rather than the exception. Now the stove founder is as anxious to attain maximum production as the farmer, the ship builder or the munitions maker. The new plant of the Cleveland Co-Operative Stove Co. is a good example of a plant designed to insure heavy production as well as favorable working conditions for the workmen.

The building was begun in the fall of 1916, the flood of orders for stoves at that time forcing officials of the company to realize how totally inadequate the old shop was to meet them. It was expected that the foundry would be completed late in February, in ample time to store a stock of stoves for the busy season of the present year. Labor conditions and transportation facilities, however, were disappointing; consequently, the work of construction was delayed and the building was not completed until the early part of July. The plant is located on Harvard avenue, opposite the Newburgh works of the American Steel & Wire Co.

The new foundry is 135 x 500 feet, of brick and steel construction. About 400 tons of fabricated steelwork were used. Plans for the building were prepared by Geo. S. Rider & Co., Cleveland, and the building was erected by the National Concrete & Fireproofing Co., of the same city. The steelwork was fabricated by the Penn Bridge Co., Beaver Falls, Pa.

The roof is of the Pond truss type, the lowest point of the monitor being about 2 feet above the level of the side sections of the roof. Three tiers of steel sash, manufactured by the David Lupton Sons Co., Philadelphia, parallel either side of the monitor and a similar number traverse

FIG. 2—FIFTY MOLDING MACHINES ARE EMPLOYED IN THE MACHINE MOLDING SECTION

FIG. 3—THE CLEANING ROOM AND THE SHIPPING ROOM OCCUPY THE NORTHWEST CORNER OF THE FOUNDRY

the side walls of the building. Part of the end walls likewise are composed of glass, bringing the total percentage of sash area to about 90 per cent of the total wall area. Splendid light is thus afforded the workmen and the ventilation is such that no ventilators are required to remove the fumes from the molding and cleaning rooms. The problem of artificial illumination also has been solved with equal care. High-power incandescent lamps are suspended in rows of five each, a space of 19.3 feet separating each row. The total number of lamps used is approximately 125. The lights are controlled from a switchboard in the air compressor room.

One of the outstanding features of the foundry, extremely noticeable to an outsider first entering the plant is the fact that not a single crane or hoist of any character is used. The molded stove plates and sections are comparatively light, permitting them to be transferred from one department to another by trucks and wheelbarrows. Electric trucks of the low platform type are employed.

An idea of the general arrangement of the plant may be secured from Fig. 1. The two main bays, each 60 feet wide and 450 feet long, are separated by a 15-foot runway which runs the entire length of the foundry. The east bay is used exclusively for molding, while the west bay accommodates one molding floor and the melting, cleaning and shipping departments. The molding floors occupy between 65 and 70 per cent of the floor area of the entire foundry. Early specifications called for a monorail system to be located in the 15-foot runway, but it was finally decided that the gain from a system of this character would not warrant the expenditure connected with its installation. The greater part of the molding on this floor, consisting mostly of smaller work, is done with molding machines made by the Osborn Mfg. Co., Cleveland. These machines are operated by compressed air, and straddle the heaps of molding sand. This arrangement enables each molder to move his machine along the floor as his day's work progresses. Some hand molding also is done in this bay on work benches, which, like the squeezing machines, straddle the heaps of sand and move on their own wheels. The work done in the hand-molding section is of a slightly heavier nature than that performed on the machines. The heaviest molding is done in the opposite bay in the space between the core room and the cupola. The molding floors are indicated in Fig. 8, which is a plan view of the foundry.

Arrangement of Charging Floor

The melting equipment, shown in Fig. 4, is conveniently situated in the middle of the right-hand bay, equidistant from the extremities of all of the molding floors. The 84-inch cupola, built by the W. W. Sly Mfg. Co., Cleveland. melts about 40 tons of pig iron daily. The charging floor is 35 x 75 feet and is accessible by a stairway in the rear and by an 8000-pound capacity elevator made by the Otis Elevator Co., New York. A 6000-pound capacity scale, made by the Standard Scale & Supply Co., Pittsburgh, is located immediately in front of the elevator. The charging floor is easily capable of holding two carloads of coke and 200 tons of pig iron, which constitute about a week's sup-

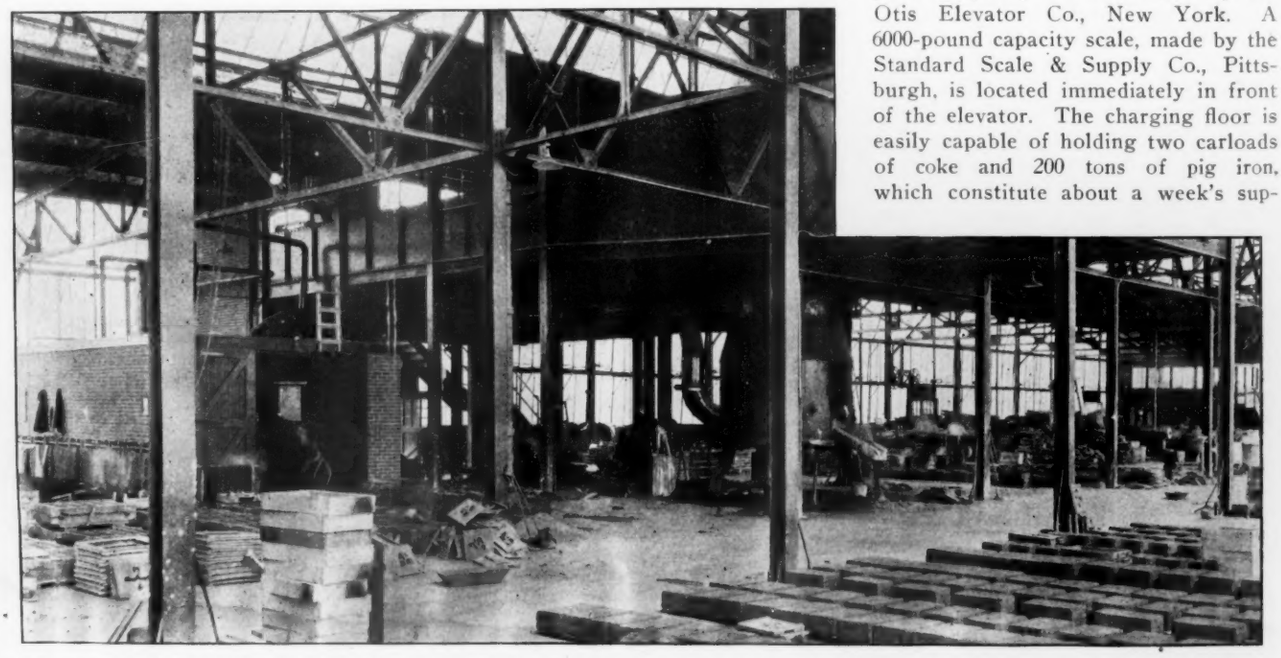


FIG. 4—THE CHARGING FLOOR AND THE CUPOLA OCCUPY THE CENTER OF THE EAST BAY—THE AIR COMPRESSOR AND BLOWER ARE HOUSED IN THE ROOM SHOWN AT THE LEFT

ply. The floor is of reinforced concrete, protected on its upper surface with ⅜-inch steel plates.

Iron is distributed to the molding floors by hand ladles. The iron in the cupola drop is reclaimed by a cinder mill located about 20 feet from the cupola.

The core room occupies an area 50 x 135 feet at the south end of the foundry. As shown in the plan view, this room is divided into two sections by the 15-foot gangway, the section in the west bay tapering from 50 feet in width down to a point. The peculiar construction of the latter room is caused by a corner of the foundry having been cut off in order to accommodate the railroad siding. One core oven of the drawer type serves the requirements of the entire shop. This oven is 18 x 10 x 8 feet and was made by the W. W. Sly Mfg. Co., Cleveland. Cores are made on benches in the core room, and after baking are placed on movable racks and transferred to the molding floors. The oven, shown in Fig. 6, is fired from a pit at one end. Fig. 6 also shows a sand-mixing machine, made by the Sand Mixing Machine Co., New York. This machine is kept in the core room in the day time and prepares the molding sand during the night.

Blower Driven by Alternating Current

The blast for the cupola is furnished by a blower installed by the P. H. & F. M. Roots Co., Connersville, Ind. The blower is driven by a 50-horsepower alternating-current motor made by the Lincoln Electric Co., Cleveland, and provides a blast pressure of 14 ounces. The blower is housed about 40 feet from the cupola on the main floor.

The air compressor which supplies air for the molding machines is located in the room containing the blower and elevator machinery. It is driven by a 50-horsepower alternating-current motor, and provides a pressure averaging approximately 100 pounds.

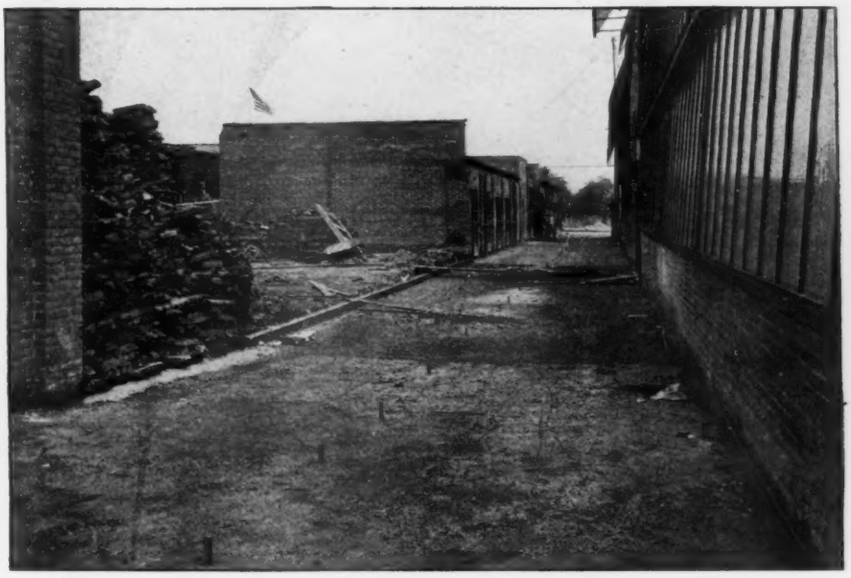


FIG. 5—THE RUNWAY BETWEEN THE STORAGE BUILDINGS AND FOUNDRY PROPER WILL BE PAVED WITH CONCRETE

The cleaning room, located north of the cupola in the east bay, is approximately 60 feet square. The equipment in this room includes 24 tumbling barrels made by the W. W. Sly Mfg. Co., and four double grinders, made by the Bridgeport Safety Emery Wheel Co., Bridgeport, Conn. Like the air compressor and blower, this equipment is operated by alternating current. As shown in Fig. 3, the tumbling barrels are arranged in four groups of six barrels each and the grinders are placed in a line about 10 feet apart, parallel to the barrels. This arrangement facilititates the transfer of castings for the two operations.

The blower system for the cleaning department, installed by the Ohio Blower Co., Cleveland, is claimed to be unique. One 5-inch exhaust pipe is connected with each separate tumbling barrel and one 4½-inch. pipe with each double grinder, making 28 pipes in all. The 70-inch fan is operated by an alternating current motor. All of the exhaust pipes converge in a cyclone on the roof where the dust is separated from the air by centrifugal force, the dust falling into a waste pipe from which it is removed in trucks.

The shipping room adjoins the cleaning room and occupies approximately the same amount of floor space. Inasmuch as the company was unable to bring the railroad siding

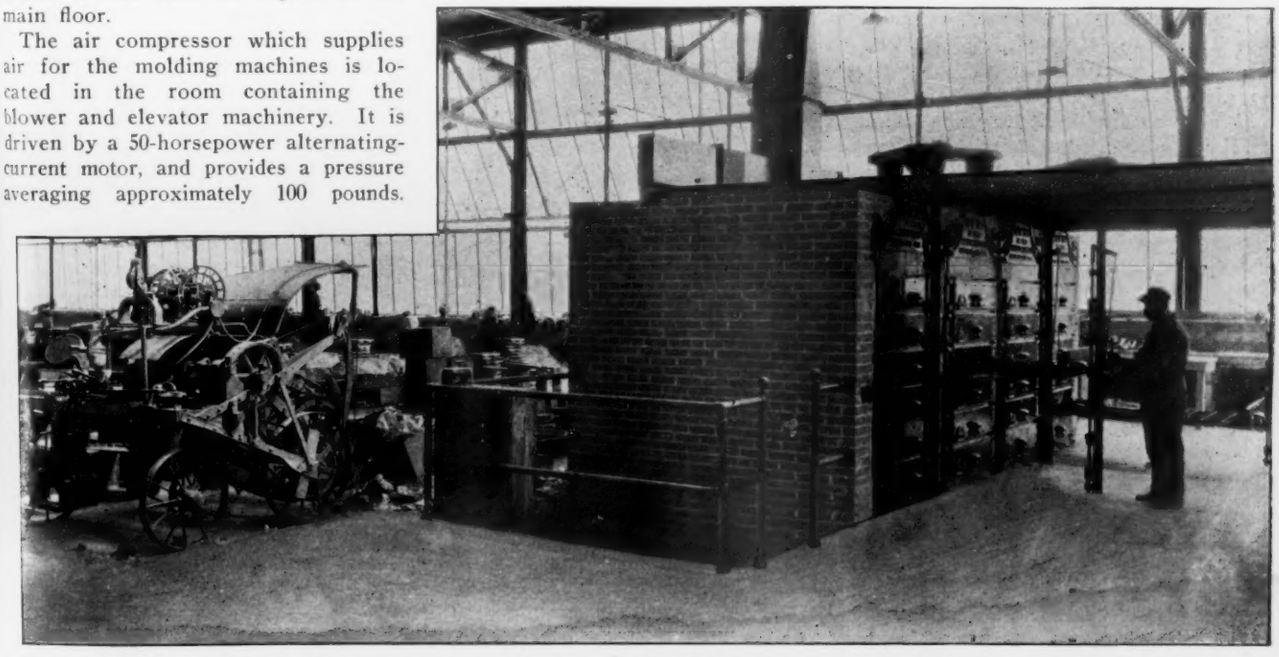


FIG. 6—THE CORE OVEN IS OF THE DRAWER TYPE—THE SAND MIXING MACHINE SHOWN AT THE LEFT PREPARES THE MOLDING SAND DURING THE NIGHT

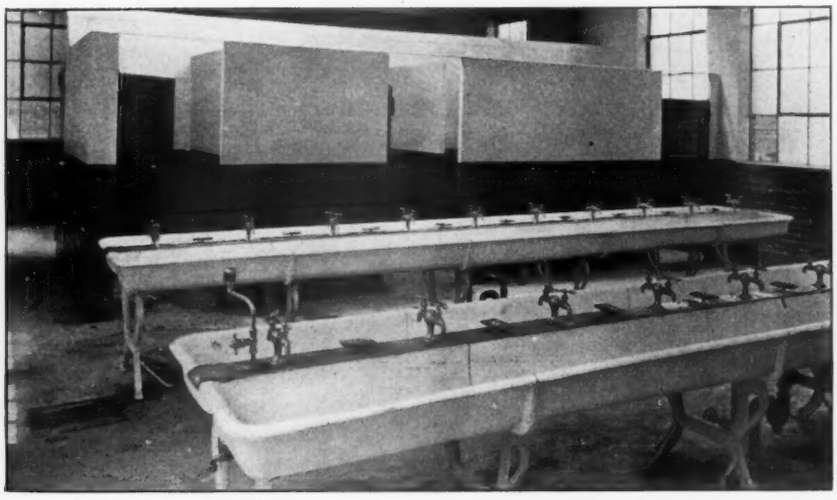


FIG. 7—SHOWER BATHS ARE PROVIDED FOR THE MEN

alongside the shipping room, it was decided to pave the way to the siding, enabling the finished products to be trucked over this expanse in all kinds of weather. This arrangement turned out so satisfactorily that it was decided to pave the yard between the main buildings and all outbuildings. Fig. 5 illustrates this long passageway and shows the first filling of concrete.

Storage Buildings

The sand limestone and clay are stored in reinforced concrete and brick buildings immediately outside the main buildings, as shown in the plan view. Coke and pig iron are stored in the open, opposite the elevator leading to the charging floor. Trucking of all outside material is greatly facilitated by the concrete runway.

The floors of all departments of the foundry are of concrete laid by the National Concrete & Fireproofing Co. A metallic hardening, manufactured by the Master Builders Co., Cleveland, is mixed with the concrete to give it a hard and tough surface and also to enable it to keep from cracking under contact with molten iron. The 15-foot runway has been especially treated with this substance.

Lockers for the men are located in the small building on the Harvard avenue side of the foundry. This arrangement enables the men to change clothes before and after working hours. The locker room is partitioned off from the wash and shower bath room, as shown in the plan view. Drinking fountains are placed at convenient points throughout the shop.

The site on which the foundry stands is 250 x 900 feet. The foundry was erected under the direction of J. H. O'Brien, president of the Cleveland Co-Operative Stove Co. Other officers of the company are: J. T. Gill, vice president; W. W. Ludlow, secretary and treasurer. James Mitchell is general superintendent. The old foundry will continue in operation, until further construction planned on the new site is carried out. Scarcely any of the labor in the old plant was transferred to the new plant, almost all of the 250 workmen having been secured from outside sources.

It is a popular theory that nickel will cause lead to remain in solid solution with copper, but as a matter of fact lead is only partly miscible with nickel and copper in the molten state. The temperature of complete solidification of the mixture is identical with the solidification point of lead, and the constituents of such alloys are solid solutions of copper and nickel and nearly pure lead.

Preventing Cupola Bridging

By W. J. Keep

Question.—Our cupola is only 26 inches in diameter and in making heats averaging 3000 to 3500 pounds, it bridges above the tuyeres. We do not slag-off throughout the entire heat. The furnace is provided with six tuyeres located 12 inches from the bottom and we would like to have you advise us whether we should close one-half of these.

Answer.—It requires considerable experience and great care to melt iron satisfactorily in a small cupola. The pig iron and scrap should be broken small and should be charged very evenly and no dirt should be thrown into the stack. Screen out all small iron particles and shot and place them on the sand bottom or on top of the last charge. The tuyeres should be as large as possible, 12 inches being approximately the right height. If you exercise care you should be able to melt the amount of iron mentioned without much difficulty. You can overcome all of your trouble by slagging. No cupola should be run without the slag hole open, especially a furnace of such small diameter.

When cerium is heated in an atmosphere of hydrogen it rapidly absorbs this gas at about 350 degrees Cent. Between 450 degrees and 510 degrees Cent. the dissociation pressure is about 1 millimeter corresponding to CeH_2; beyond this the dissociation pressure increases with the hydrogen concentration. It is probable that when cerium takes up hydrogen that the hydride is first formed and the hydride then dissolves more hydrogen.

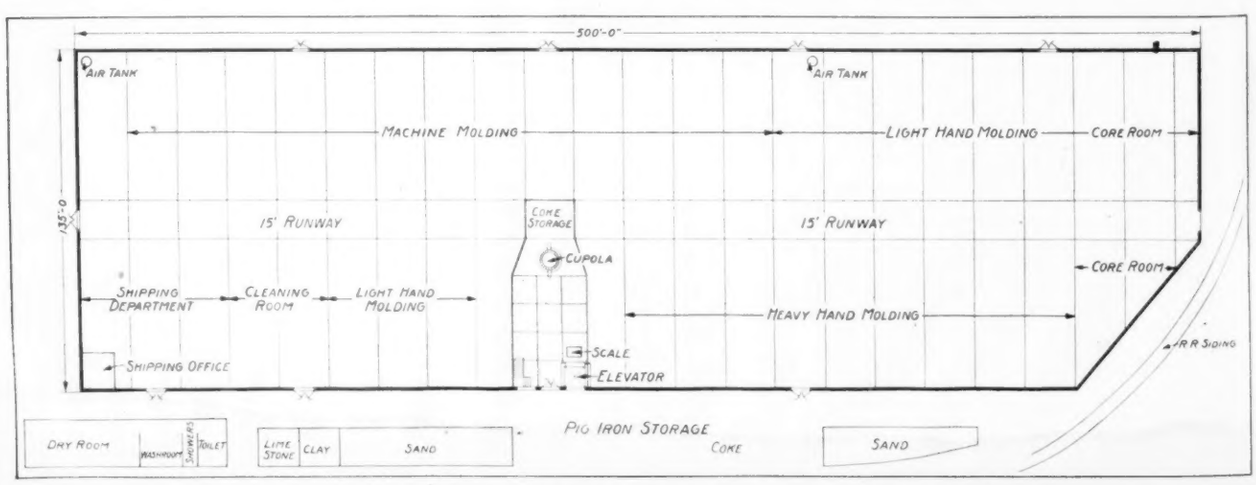


FIG. 8—PLAN VIEW OF NEW FOUNDRY OF CLEVELAND CO-OPERATIVE STOVE CO.

Institute of Metals Prepares a Great Program

Tentative List of Papers Announced Forecasts Interesting Meeting at Boston —Manufacturers' Reservations Insure Success of Foundry Equipment Show

ALTHOUGH the opening date of the great exhibition of foundry equipment and supplies, machine tools and accessories, to be held at Boston, beginning Tuesday, Sept. 25, is nearly two months distant; a total of nearly 40,000 square feet of floor space already has been reserved by 120 manufacturers. This foreshadows the biggest show of its kind ever held in New England and promises to eclipse, both in size and number of exhibitors, any previous undertaking by the American Foundrymen's association.

The general arrangement of Mechanics building, where the exhibition will be held, adapts itself unusually well to the unusual types of displays that will be made. Still exhibits will be located in one section of the building, apart from the operating displays, and all of the heavy machinery will be placed in one part of the hall at a distance from the still exhibits. In view of the uncertainty of railroad facilities during the months of September, and the delays in shipping already experienced, C. E. Hoyt, exhibition manager, has requested manufacturers to ship their equipment as far in advance of the opening date as possible. Storage space has been obtained in Mechanics building of sufficient capacity to take care of all of the equipment that is delivered in August and early in September.

The committees of New England foundrymen are busily engaged in making arrangements for the reception and entertainment of the large number of foundrymen who will attend this big event.

Program of Institute of Metals

W. M. Corse, secretary of the American Institute of Metals has issued the tentative program of the annual meeting of his organization, which will be held concurrently with the convention of the American Foundrymen's association. An imposing array of papers will be presented on various subjects of practical interest to brass foundrymen. Separate sessions will be devoted to the discussion of crucibles and furnaces, the melting and casting of nonferrous metals, casting alloys in connection with the manufacture of munitions, the testing of nonferrous metals and metallography.

The papers which have been selected deal with subjects of unusually timely interest to foundrymen. The tentative program is as follows:

Crucibles and Furnaces:

"The Crucible Situation," by Prof. A. V. Bleininger, Bureau of Standards, Pittsburgh, Pa.

"Melting Yellow Brass in New Form of Induction Furnace," by G. H. Clamer, Ajex Metal Co., Philadelphia, Pa.

"The Crucible Situation," by M. McNaughton, Jos. Dixon Crucible Co., Jersey City, N. J.

"The Electric Furnace and Nonferrous Metals," by Dwight D. Miller, The Society for Electrical Development, New York City.

"My Experience with Metal Melting Furnaces," by W. H. Parry, National Meter Co., Brooklyn, N. Y.

Melting and Casting Nonferrous Metals:

"Casting Bearings in Sand and Metal Molds," by R. R. Clarke, Pittsburgh, Pa.

"The School End of the Job in Training Foundrymen," by C. B. Connelly, Dean, Carnegie Institute of Technology, Pittsburgh, Pa.

"The Flux and Cleaner Question of Brass," by E. D. Frohman, S. Obermayer Co., Pittsburgh, Pa.

"Negative Experiments on Waste Core Sand," by Dr. H. W. Gillett, Bureau of Mines, Ithaca, N. Y.

"Pyrometers—Their Construction and Application," by John P. Goheen, Brown Instrument Co., Philadelphia, Pa.

"Surface Tension and Deoxidizing of Metals," by W. J. Knox, Metals Deoxidizing & Refining Co., New York City.

"The Briquetting of Nonferrous Light Metal Scrap," by A. L. Stillman, General Briquetting Co., New York City.

"The Swelling of Zinc Base Die Castings," by H. M. Williams, National Cash Register Co., Dayton, O.

Munitions, Etc.:

"The Present Status of Tin Fusible Plug Manufacture and Properties," by Dr. Geo. K. Burgess and Mr. Gurivitch, Bureau of Standards, Washington, D. C.

"Stellite," by Elwood Haynes, Haynes Stellite Co., Kokomo, Ind.

"Fire Prevention in Large Industrial Establishments," by C. W. Johnson, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

"The Use of Die Casting in Munitions," by Charles Pack, Doehler Die Casting Co., Brooklyn, N. Y.

"A Few Points on Alloy Patents," by Wm J. Rich, Government Patent Office, Washington, D. C.

"Shrapnel Bullets," by Harold J. Roast, the James Robertson Co., Ltd., Montreal, Can.

"Recent Industrial Uses of Aluminum," by F. G. Shull, Aluminum Co. of America, Boston, Mass.

Testing Nonferrous Metals:

"Some Comparative Tests on Test Bars and Actual Castings," by W. M. Course, the Titanium Alloy Mfg. Co., Niagara Falls, N. Y., Buffalo, N. Y.

"Analysis of Babbitts and Brasses," by E. W. Hagmaier, Buffalo, N. Y.

"Standard Test Bars of 88-10-2 and 88-8-4, being the result of co-operative work of six foundries; a new series of tests," by C. P. Karr, Bureau of Standards, Washington, D. C.

"The Expansion Co-efficients of Alpha and Beta Brass" and "The Corrosion of Manganese Bronze Under Stress," by Dr. Paul D. Merica, Bureau of Standards, Washington, D. C.

"Corrosion of Brasses of the Muntz Metal Type," by H. S. Rowdon, Bureau of Standards, Washington, D. C.

"Analysis of Cadmium in Brass," by Dr. F. Schramm, Bureau of Standards, Washington, D. C.

Metallurgy and Metallography:

"The Electrolytic Production of Antimony," by Prof. D. J. Demorest, The Ohio State University, Columbus, O.

"The Electrical Properties of Some High Resistance Alloys," by Prof. M. A. Hunter, Rensselaer Polytechnic Institute, Troy, N. Y., and F. M. Sebast.

"The Amorphous Theory in Metals," by Prof. Zay Jeffries, Case School of Applied Science, Cleveland, O.

"The Uses and Metallurgy of Antimony," by K. C. Li, Wah Chang Mining & Smelting Co., Inc., New York.

"Development and Reabsorption of the Beta Constituent in Alloys which are normally of the Alpha Type," by Prof. C. H. Mathewson, department of mining and metallurgy, Yale University, New Haven, Conn., and Philip Davidson.

Analysis of Alloy Corrected

On page 273 of the July issue of THE FOUNDRY a table was published containing the following caption: "Physical Properties of the Alloy: Copper 80 Per Cent; Tin, 10 Per Cent; Zinc, 10 Per Cent." This alloy should have been: Copper, 80 per cent; tin, 10 per cent, and lead, 10 per cent, as with 10 per cent of zinc, the alloy would have been glass-hard.

The American Foundry Equipment Co., New York, recently issued an attractive sand-blast catalog which illustrates and describes the complete line of machines built by this company.

The Kirk Supply Co., Pittsburgh, recently has received a number of contracts from foundries and iron and steel works, including the following: Twenty-five charging box cars, to be built by the Easton Car & Construction Co., Easton, Pa., for delivery to the Canton Sheet Steel Co., Canton, O.; six cars of similar type for the Edgewater Steel Co., Pittsburgh, with works at Oakmont, Pa.; complete foundry flask requirements, to be furnished by the Sterling Wheelbarrow Co., Milwaukee, Wis., for the Producers Supply Co., Franklin, Pa.; three ¾-yard concrete mixers of the Marsh-Capron type and 1000 Sterling column clamps for the Union Switch & Signal Co., which is building a new plant at Swissvale, Pa.

A Study of the Steel Foundry Sand Problem

Molding Sand for Steel Castings Must Be Plastic, Non-Yielding, Permeable to Gases, and Capable of Resisting High Temperatures

By G Muntz and E Roubien

THAT the problem of sand, for the steel foundry, has been considered a very important one for a long time is indicated by the tremendous amount of literature available on the subject. The American Foundrymen's Association undertook an exhaustive study of foundry sands in general, but the scope of the problem was so large that it had, finally, to enroll the help of the bureau of standards, at Washington, D. C. The bureau is crowded with work. It can devote but a fraction of its time to the question, so it ensues that such conclusions as it will reach will necessarily be belated. The Tropenas Converter Co., in putting its process in operation in steel foundries, was confronted with this sand problem several years ago, and worked out a solution satisfactory to its engineers.

The data gathered at the time were boiled down, and a set of instructions were adopted. These instructions included reasons for the solution reached and the problem was reviewed from all angles. In the belief that the data would be of interest to the foundry industry they are being published today for the first time.

Physical Composition of Sand

It is well to remark, at the beginning, that in the steel foundry, we are in the presence of the highest temperatures at which ferrous metals are cast. We have, therefore, to deal with the most arduous problem involving refractoriness of molds.

The qualifications of sand suitable for molding are the following:

Molding sand, it is pointed out by Dr. Moldenke, must be plastic, non-yielding, permeable to gases, capable of resisting high temperatures readily, and after serving its purpose, must be easily destroyed. Furthermore, if any material answers all these conditions, its cost will have to be considered, in order to ascertain whether the advantages expected from its use are not secured at prohibitive expense.

Molding materials are used throughout the country; they should, on this account, consist of minerals very widely distributed in nature, thus explaining

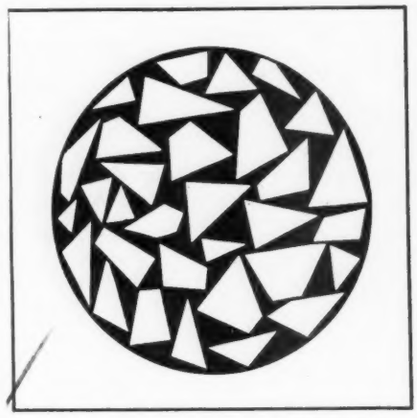


FIG. 1—SHARP SAND RAMMED IN A MOLD, SHOWING LARGE VOIDS

why sand has been, from time immemorial, used for the purpose. It consists chiefly of silica, which, next to oxygen, is the most abundant element in existence. It has a very high melting point and is found in small particles which will readily espouse and reproduce the shapes to be molded. This granular texture will also provide such voids as will permit of easy evacuation of the gases and steam evolved in the molds while pouring. But the various particles of silica do not adhere to each other naturally, thus an agglomerating medium will have to be called upon, if the good qualities of silica are to be taken advantage of.

Clays have been chosen to agglomerate silica because they are themselves refractory and can be found most anywhere; some have no plasticity and are, therefore; of no value to cement the silica

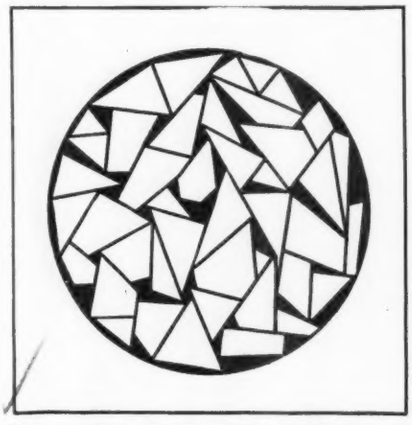


FIG. 2—THE SAME SAND RAMMED IN A DIFFERENT MANNER WITH LESS VOIDS

particles, while others, for some reasons yet unknown, will form with pure silica, a plastic compound which is most suitable as a molding medium.

There are other refractory materials possessing a much higher melting point than silica, but on various accounts are not used for molding. Thus, certain clays such as the kaolins, fuse at temperatures above those usually encountered in the steel foundry, but molds made of these would have to be dried thoroughly in order to be non-yielding and in drying would shrink to such an extent, and so irregularly, that it would be almost impossible to preserve trueness to pattern. Besides, permeability to gases would be almost nil, and the destruction of the molds, after serving their purposes, would be most difficult.

Either magnesia, lime or alumina are more refractory than silica, but not as widely distributed, and all lack some of the qualities indispensable to molding media.

It seems then that sand, consisting of silica, clay, and their inherent impurities, is the only material we can use for molding purposes. We will, therefore, continue our study on that basis.

Chemical Composition of Sand

Silica is found, in the natural state, generally as quartz, which is almost pure SiO_2. Silica melts at about 1,600 degrees Cent. (2,900 degrees Fahr.); it contains as impurities affecting its melting point, alkalies, basic fluxes and metallic oxides. But these are present in very small quantities and have practically no effect on the whole, so we can safely say that ordinary pure silica sand does not melt at the temperatures encountered in steel molds.

However, silica cannot be used alone, and as we have already seen, admixtures of clay must be made to agglomerate the mass. It thus behooves to ascertain what effect heat has on clay. To those who want detailed information on the subject, we would recommend "Technologic Paper No. 7, The Testing of Clay Refractories," issued by the bureau of standards, Washington, D. C. For the purpose on hand, the following resume will answer.

"The principal ingredient of fire clays is a hydrous silicate of alumina, or kaolinite, of the formula Al_2O_3, $2SiO_2$, $2H_2O$ corresponding to the following

From the February, 1917, issue of *Steel Castings*, published and copyrighted by the Tropenas Converter Co., New York. The authors, G. Muntz and E. Roubien, are with the Tropenas company.

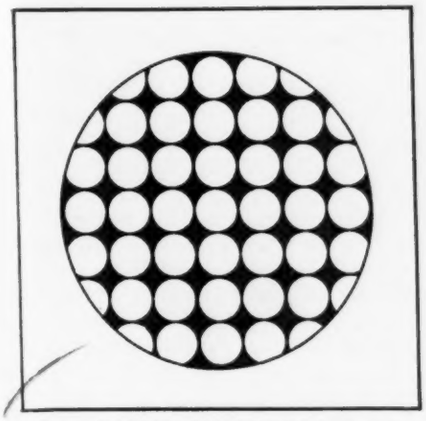


FIG. 3—ROUND SAND RAMMED IN A MOLD SHOWING CONSTANT VOIDS

percentage of silica, aluminum and water:

	Per cent.
Silica, SiO_2	46.3
Alumina, Al_2O_3	39.8
Combined water	13.9

While this substance, commonly called kaolin, does not correspond to the most refractory mineral combination of silica and alumina found in nature, it is at least, the most commonly distributed material, since it may be assumed to be the fundamental constituent of all fire clays." It melts at about 3,200 degrees Fahr.

Composition of Clays

Clays, however, are seldom found pure, and contain quite considerable proportions of alkalies, lime, magnesia, ferric oxides, and free silica. Let us see what action these different impurities have on clays under the influence of heat.

Alkalies—These have a relatively low melting point (2,550 degrees Fahr.). They are so called neutral fluxes, as they do not unite with pulverulent silica, but dissolve it, thereby reducing the general refractoriness of clays to a large degree.

Lime—This element, united with silica, forms very fusible silicates which deform and flow at the temperature of liquid steel.

Magnesia—Magnesia acts very much like lime, but not in as marked a degree. It lowers the melting point of the silicates already formed, but not as strongly as ferrous oxide.

Iron Oxide—This impurity being present in a finely divided condition, acts as a very potent flux, and is most injurious to fire clays at high temperatures.

What really happens is a dissociation of the higher oxides into the lower form FeO which, at the temperature involved, combines with silica to form ferrous silicate. This silicate is highly fusible and results in a strongly corrosive slag which attacks clay most vigorously.

Silica—Free silica in clay acts as an impurity, as it serves to lower the melting temperature. We will see later that for molding purposes, clays are ground very fine, so that the silica they contain, will itself be present in extremely fine particles, these are dissolved by the alkalies, as seen above, and when liquid, act in turn as solvents of alumina, thereby lowering the melting point of the clay.

The foregoing can further be condensed as follows:

Steel molding sand is a compound of silica and clay.

Silica expands when heated, counteracting clay which contracts.

Clay is a fine grained mixture of kaolinite and impurities consisting of free silica, iron oxides, lime, magnesia, and such alkalies as are carried by natural feldspars.

Weber shows that when a clay is heated gradually to complete fusion, at first fritting occurs, then the neutral fluxes fuse and the liquid part gradually dissolves the adjoining particles, first siliceous, then aluminous, the fine particles more readily than the coarse until finally the whole has been liquefied to a homogeneous solution.

In the steel foundry, clay is, therefore, the necessary evil, as it is the carrier of the fluxes which attacks the almost pure silica of sand.

If we now compare these requirements to those expected of sand, we find that our problem is almost solved because silica mixed with very little clay is:

1—Plastic on account of the mobility of its particles and the plasticity of the bond.

2—Almost infusible at molten steel temperature.

3—Most unyielding, inasmuch as the quartz forming its foundation is one of the hardest minerals known.

4—Will be easily broken up after serving its purpose, as clay will not be present in sufficient quantities to give the mass of brick-like structure, and easy fritting will ensue after exposure to heat.

5—Very economical on account of the wide distribution of the components, their easy availability and their ensuing low cost.

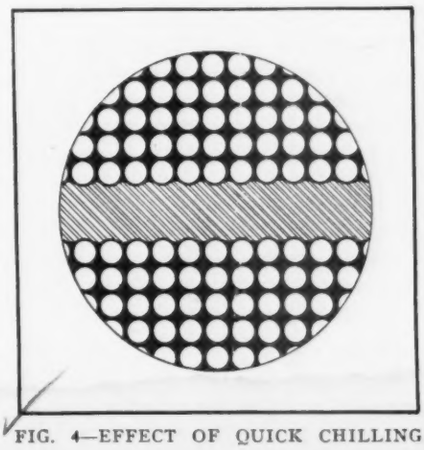


FIG. 4—EFFECT OF QUICK CHILLING

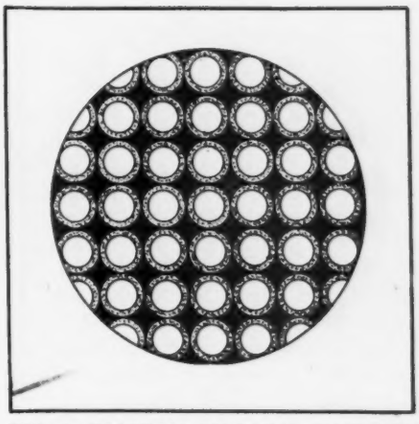


FIG. 5—DIAGRAM OF IDEAL FOUNDRY SAND

The point in doubt covers, therefore, permeability to gases and steam.

The open spaces which exist between the various particles of sand, measure the extent of permeability to gases and steam. Let us suppose that the particles are angular, namely, composed of flat surfaces meeting in the shape of sharp angles. In ramming up a mold, we have no control whatsoever over the orientation which the various particles will assume, so that sand, in a mold, will appear in cross section, either as shown on Fig. 1 or as illustrated by Fig. 2. In the first case, we have greater permeability than in the second, although dealing with exactly the same material.

If we now consider spherical particles as shown on Fig. 3, we will note at once, that no matter how we ram our sand, and disturb its elements, the voids left between them will remain the same, resulting in the preservation of such constant degree of permeability as is deemed satisfactory.

Sands as provided by nature, are usually round grained, and, if they meet the chemical requirements, they represent the class used in the steel foundry.

Influence of Grain Shape and Size on Refractories

It is a plain matter of common sense to state that a small piece of sugar will dissolve faster, in a glass of water, than a larger piece. The same applies to silica taken up in solution by impurities melting at a lower temperature. Thus, crushed silica will see its sharp edges molten very rapidly, while round grained silica will present an almost solid front to melting influence. This is another argument in favor of the latter sand.

On the other hand, a very small round grain of silica will be easily taken up in solution, while too coarse a one will produce rugose walls in the molds, and, therefore, rough castings.

Fineness means also, decreased permeability to gases, so that sand will have to be graded, as to grain, by the foun-

dryman to meet his particular requirements in this respect.

If small castings of thin section are to be produced, the metal when coming in contact with the sand will chill rapidly and will not readily attack the walls of the mold. On the other hand, and on account of the same fear of rapid chilling of the metal, gases must be quickly evacuated; thus a fairly large grain, insuring great permeability, seems indicated. In Fig. 4 we have purposely exaggerated the size of the sand grains in order to show how quick chilling of the metal prevents it from entering every little wall cavity, thereby ensuring smooth castings with relatively coarse sand.

When making castings of heavier section, the bodies of metal remain liquid longer and are more apt to seriously impair the walls of the molds. Very smooth and continuous mold surfaces are, therefore, required, meaning a smaller grain with its decreased permeability. In this case, however, gases have plenty of time to escape before the metal solidifies, and fineness is not at all objectionable on that score, but greatly beneficial in obtaining smooth castings.

In the case of large castings of heavy section, the facing sand should still be finer, but owing to the length of time the metal will then remain liquid, and the ensuing larger quantities of gases and steam to be evacuated, it will be well to either back the facing with coarser sand or else vent the mold profusely. Thus we come to the conclusion, quite at variance with usual practice, that sand must be relatively coarser to produce small castings than to turn out large ones.

Natural Sands

The first question coming to mind is that, as nature is usually a good provider, there might be some sands which in the original state, are suitable for steel molding. Nature made two great divisions. The first covers sands consisting mostly of pure silica, having, therefore, no bonding power without suitable admixtures of clay; the second offers sands which are already composed of silica and clay. We find the latter materials in the trade under the name of strong silica sand, while the former are called sharp silica sand. (Why sharp, we do not know.)

Nature, however, intended sands for a multitude of other uses than the steel foundry. It is then not surprising that the strong silica sands available differ very widely in composition with the localities in which they are found, and that extensive variations occur even in the different parts of the same quarry.

The only conclusion to be drawn, is that on account of uncertainty as to the proportion of the components, the steel foundryman using strong sand, is always in the dark as far as clay contents are concerned. The average analysis might be satisfactory, but fluctuations are so wide, even in one carload, that strong silica sands do not seem advisable for steel foundry use.

The Ideal Steel Foundry Sand

For permeability's sake, silica should present itself in particles as spherical as possible and these, having no cohesive attraction for each other, must be mixed with clay bond. It behooves us, therefore, to determine in what shape this clay bond should be introduced in our ideal sand.

In ramming the sand in molds, the particles are disturbed from the position they occupied when first thrown in; any given one must then be self supporting and be able to adhere to any and all of its neighbors and therefore must be thoroughly covered with the bonding material.

Clay is the enemy, it fuses at high temperatures, on account of the impurities it carries, and because of its very fine texture. The coating of clay that each particle of silica is to receive should then be reduced to a minimum.

Ideal foundry sand is shown schematically in Fig. 5 and is defined as an agglomeration of spherical particles of silica, each covered with as thin a coating of clay as can be applied on them.

To cover each particle of silica with as thin a coating of clay as possible, two conditions must be fulfilled, namely, the silica must be rolled in clay through adequate means, and the clay must be susceptible of assuming the nature of a thin coating.

The first condition is easily met, as we shall see later, but the second is very difficult to fulfill in practice. Clay is one of the most difficult materials to grind; not that it is hard, but being plastic, the least humidity will cause it to lump, and if clay in any amount is localized in sand, contact with hot metal will melt it, and the result will be lumps and burned in sand on the castings.

To achieve extreme fineness, clay must be ground absolutely dry, and then driven through an air separator, which accepts the very fine material and rejects the lumps and grits.

This operation is called air floating. It consists merely in grinding the clay and dropping it in a chamber from which the air is drawn by a strong exhauster. The light material is carried off by the air while the heavier falls by gravity and is returned to the grinders. Water floating achieves better results, but is slow and wasteful.

Air floated clay will average from 95 to 98 per cent fineness through a No. 200 sieve, and it is useless to state that if properly handled, this material will be ideal for use, in connection with such silica sands as are almost devoid of bond.

Covering the particles of silica with as thin a coating of clay as possible can only be accomplished by rolling them in the clay. None but spherical, cylindrical or conical objects will roll, but only the spherical ones will become entirely covered, as the other two have always more than one point in contact with the bond, and the ends will never become coated regularly.

Round grained, sharp silica sand mixed with thoroughly air floated clay will, therefore, give ideal steel foundry sand. To mix these two constituents according to the rules already laid down, mechanical means must be devised. Complicated machinery meant for this purpose, can be found on the scrap heap of many a steel foundry. The old pan grinder seems yet the most efficient, although many of its users do not quite understand why.

Let us consider a grinder in which the pan is driven and the rollers revolve on account of the pan's tractive effort. As soon as motion obtains, we can see that on account of difference in speeds, between points on the pan and corresponding points on the rollers, a slippage will occur between them, causing the particles of materials in between, to be rubbed together, thus achieving the ends in view. This same rubbing effect can be obtained with a stationary pan and driven rollers, but in this case the slippage is not as appreciable unless the rollers are made very wide of face. To increase slippage, some rollers are grooved with resulting quicker operation.

Sand Specifications

Our experiments on this subject are not complete but general data are already available as follows:

It is evident that ideal conditions would be obtained if the spherical particles of silica were of equal size. Silica sands, however, cannot be obtained of uniform grain, they should then be specified as round grained and as passing entirely through a maximum mesh, to be selected to suit the work on hand, while only a certain percentage will be allowed to pass through a minimum mesh. This condition insures adequate porosity to gases, as it eliminates the small material which clogs the spaces left between the larger particles.

In a chemical way, silica sand will be specified as containing no less than 98 per cent silica so that little room will be left for impurities.

The clay must be specified by chemical analysis to come as near as possible to the ideal composition of kaolinite, namely, silica from 35 to 50 per cent, alumina from 30 to 40 per cent, alkalies, lime, magnesia, iron oxides to total less

than 5 per cent, the remainder to be combined water. Physically, clay will be specified as plastic and passing not less than 95 per cent through a 200 mesh.

It is necessary to point out here, that two sands of identical chemical and physical composition will not always give the same results. This is due to the fact that clays vary in plasticity and bonding power, although showing almost identical chemical analysis. There are no reliable methods to measure this factor, although the dye absorption test advocated by the American Foundrymen's Association might give valuable indications. This is based on the fact that fat clays absorb more dye than lean ones, and is described as follows:

"Use 0.75 gram of anilin green (malachite) dissolved in 250 cubic centimeters of water, shaking five minutes. Add 25 grams of the clay and shake in machine for 10 minutes, then pouring in a settling bottle. Let stand over night. Compare with standard solution of 0.75 grams dye in 250 cubic centimeters of water, shaken and let stand in the same way."

Reclaiming Old Sand

Under repeated reheating to high temperatures, the quartz in sand undergoes two changes. *First*, a number of particles are broken up resulting in easily fused sharp edges, and also in a smaller grain; *second*, such particles as are not broken up increase very rapidly in volume, to the extent of 20 per cent after a short time. This is due to the change from quartz to tridymite as shown by various authorities. Grum-Grzimailo shows that quartz heated to 1,000 degrees Cent. for some time, changes to tridymite with an increase in volume of 14.2 per cent (corresponding to a decrease in specific gravity from 2.65 to 2.32).

On the other hand, clay through fluxing by its impurities, and also on account of exposure to high temperature, loses plasticity, as it is then made to carry more and more inert matter. This explains why in foundries using constant percentages of old sand in their facing mixtures, the appearance of the castings deteriorates quite rapidly. This deterioration is, however, slow enough not to be observed at once by those actually producing the castings, and it often requires a disinterested outsider to point out slow degeneration of quality on this score.

If old sand is used, without any treatment, trouble is bound to ensue, and common sense indicates that by preaching due economy to the molders, thereby reducing the consumption of facing sand to a minimum, nothing but new sand should be used.

To reclaim the live materials from old sand, seems to us an even more wasteful process than throwing the old sand away. The various particles of sand cannot be separated wet. If old sand must be used, it should, therefore be dried, ground and screened to both a minimum and maximum mesh, before going back into new facing. But even after all these costly manipulations, the chemical contents would still be doubtful. Therefore, we ask, is the gain worth the trouble?

Use of Silica Wash

When dry sand molds are found necessary, the prevailing practice is to coat the surfaces, which will come in contact with molten metal, with a wash made up of finely pulverized silica tempered with molasses water.

Such a wash will prove satisfactory, provided the sand on which it is applied is properly compounded, and offers suitable permeability to gases and steam. If the wash is applied on sand which does not answer these requirements, gases and steam will endeavor to escape into the mold, thereby breaking up the coating of silica wash and causing it to flake. This means that the main requirements of the sand are in no wise lessened by the use of silica wash, and that this practice, which possibly results in slightly smoother castings, requires just as severe compounding of the sand.

From our previous remarks it will be seen, however, that almost as smooth castings can be obtained with no wash at all, and with the further advantage of greater trueness to pattern, as any wash will have a tendency to round off corners when applied. The only advantage we can see to a wash, is that in drying, it will cause a hard skin to form on the molds, thereby preventing fritting and washing away of sand particles when the metal is poured in. Our practice has shown that molasses water sprayed over molds made of suitable sand, will achieve this purpose very satisfactorily and economically, insuring also greater trueness to pattern.

Use of Lean Clays as Bond

Mixing of silica sand and clay, is an operation involving the cheapest kind of labor. The exercise of great intelligence and attention cannot, therefore, be expected from such quarters, with the result that the proportions of the various elements, to be mixed, are not always kept as they should.

A small box or measure, is usually provided the man entrusted with this operation, and he is instructed to put so many boxes of clay to each wheelbarrow of sand. What if he puts one more or one less box of clay to the wheelbarrow of sand?

To reduce this human factor to a minimum, we strongly advocate the use of lean clays. This means lesser permeability to the sand, and lesser refractoriness, on account of the presence of larger amounts of impurities and pulverulent materials, but it prevents the vexatious variations of quality, which often cause the producer to look for trouble where none originated.

This study of the sand problem in the steel foundry is not presented as a cure to all molding troubles. The best sand, if not properly armored with nails, where the washing action of molten metal is most intense, will frit, causing scales on the one hand, and sand spots wherever the fritted material will be carried to portions where it cannot escape.

Extensive areas, such as copes overhanging large bodies of metal, will often cave in if not properly armored. In other words, our study does not eliminate the exercise of ordinary care in the use of an otherwise perfect molding material. We have only provided the foundation from which the foundryman must build, but we have not done away with the necessity of his using good judgment and common sense.

Chilling Mine Car Wheels

By W. J. Keep

Question.—Kindly let us have a good mixture for mine car wheels. The treads of the wheels should have a deep chill. We have experienced considerable difficulty in obtaining the required amount of chill. Any advice that you can give us on this subject will be appreciated.

Answer.—In a paper presented before the American Foundrymen's Association several years ago, by J. J. Porter, the following analysis of mine car wheels was given as the average of American practice: Silicon, 0.64 per cent; sulphur, 0.09 per cent; phosphorus, 0.38 per cent, and manganese, 0.44 per cent. The following analysis is suggested: Silicon, 0.60 to 0.70 per cent; sulphur, 0.08 to 0.10 per cent; phosphorus, 0.30 to 0.40 per cent; manganese, 0.50 to 0.60 per cent; combined carbon, 0.60 to 0.80 per cent and total carbon, 3.50 to 3.70 per cent.

A mixture made of this analysis will give you a satisfactory chilling iron. It will be noted that the high sulphur content is expected to impart much of the chill in the presence of the low silicon content. The carbon is rather high, since it is this element on which the sulphur acts. While modern practice depends upon chemical analysis to give the correct mixture, yet in purchasing iron it should be borne in mind that some irons take a natural chill independent of the analysis. Two pig irons having the same analysis frequently will have decidedly different chilling properties.

The Safe Handling of Crucibles in the Foundry

Experience Has Proved That Consistent Practice Assists in Prolonging the Life of Crucibles and Promotes Safety of the Workmen

THE importance of exercising special care when handling crucibles, not only to avoid accidents but also to insure greater length of service, has been greatly underestimated in the past; but in our larger plants foundrymen are now giving considerable attention to the systematic instruction of their furnacemen, melters, and helpers, with a view to keeping the number of accidents as low as possible, and obtaining the greatest number of heats from the pots.

The clay crucibles of former days have been extensively supplanted by better ones made largely of graphite which is capable of resisting exceedingly high temperatures. In fact, crucibles composed wholly of clay have practically gone out of use for the melting of steel and brass, because they can often be used for only one or two heats, and they are more likely to break or crack unexpectedly, thereby causing the workmen to be seriously burned. Moreover, the temperatures that occur in metal-working plants at the present time are higher than those that prevailed when the all-clay crucible was the standard type. The crucible that is now in general use consists mainly of the substance that is variously known as graphite plumbago or black-lead, and which is a practically incombustible form of carbon. This is combined with a small amount of clay, preferably of a special German variety, as a binding material, and perhaps a little fire sand to give the mixture an open grain, so that it can better withstand sudden changes of temperature. Some makers use, in addition, a certain quantity of material obtained by grinding old, worn-out crucibles; but this practice cannot be recommended.

Efficiency of Graphite Crucible

The graphite crucible is doubtless the most efficient yet devised, when cost and all other elements are considered, but it is, nevertheless, somewhat fragile, in view of the fact that it is expected to withstand a heat sufficient to melt refractory metals, and to support, at the same time, very considerable pressure due to the weight of its heavy fluid contents. It is exceedingly important, therefore, to see that all employes fully understand how to handle crucibles in order to reduce the danger of breakage to a minimum; and a great deal can be accomplished in this direction, because graphite crucibles, when properly made and carefully used, can be kept in a fairly safe condition.

The number of accidents from breakage is greater in small plants than in large ones, in proportion to the number of crucibles in use. This is due partly to the greater care that the crucibles receive in the large plants, and partly to the fact that large foundries buy supplies of crucibles considerably in excess of their immediate requirements, storing the surplus ones and allowing them to age or *season*. It is an old saying that crucibles improve as they grow older, and as experience shows that this belief has some actual basis in fact, the date of manufacture should be stamped upon every crucible to assist the annealing men in selecting the oldest and best seasoned of them when additional ones are required for use.

Careful Handling

Good crucibles are expensive, and every foundryman, therefore, desires to obtain the maximum service from them. The foundryman who attempts to increase the useful life of his crucibles by careful handling and by the adoption of approved methods of every other kind, is at the same time promoting safety by preventing accidents from premature breakage. Foundrymen, melters, pourers and helpers, usually expect a crucible to run a certain definite number of heats, and they are likely to be somewhat careless when a new crucible is put in service. For this reason it is wise to assign a number to each crucible, for recording the number of heats taken. The record may conveniently be kept upon a black-board, opposite the appropriate crucible number and in plain view. Everybody then knows just how many heats each crucible has run, and this knowledge often arouses a spirit of competition, which tends to make the men more careful in handling the crucibles, and to increase the service that can safely be had from them.

When crucibles are first received, it is important that they be critically examined for cracks and flaws, not only by the eye but also by tapping them with a light hammer; and all imperfect ones should be rejected. If there is evidence that any of the crucibles in a given shipment have become wet while in transit to the foundry, they should be stored for at least four or five weeks, before being used, in a place where they will dry out thoroughly, even though they may be apparently dry at the time they are received.

When a new supply of crucibles has been carefully inspected and found to be free from defects, the entire lot should be stored for a considerable time in a warm, dry place, and provision should be made to protect them as thoroughly as possible from contact with moisture or with moist air. The roof of a continuously operating core oven is an excellent place for the storage chamber.

The proper annealing of crucibles is of far more importance than is generally realized. It is said that crucibles, when they come from the manufacturer's kilns, contain less than 0.25 per cent of moisture; but after they have cooled off they absorb moisture again from the air. To anneal a crucible properly, it should first be slowly heated to a temperature somewhat above 250 degrees Fahr., and it should be maintained at this temperature for a sufficient time to remove the moisture entirely. It may then be put into service, if it has been thoroughly annealed by the makers. If there is any doubt on this point, however, the crucible should next be heated for some hours to a dull red heat, after which it should be allowed to cool again, very slowly, to about 250 degrees. In any case the crucible should still be at a temperature of 250 degrees or over, when it goes into the furnace, or the drying-out process will not be wholly successful.

Treatment Depends on Size

Large crucibles, with thick walls, require a higher temperature than small-sized ones in the preliminary heat-treatment, and a correspondingly longer *soaking* period, in order to reduce the absorbed moisture to the allowable limit. In drying out a No. 200 crucible, for example, ten hours or more should be allowed for bringing it up to a temperature of 250 degrees Fahr., and fully ten hours more should be allowed for *soaking*. If a crucible that has a considerable amount of moisture in its walls is quickly subjected to a high temperature, the moisture will be changed into steam, and this, because it is confined within the walls of the crucible, may expand so as to cause a rupture or crack. The same result may also follow from the natural contraction of the drying crucible, if the moisture is driven out rapidly or unevenly. The small pinholes and *skelping* that may often be

Compiled and published by the Travelers Insurance Co., Hartford, Conn.

seen on crucibles are caused in this way. These pinholes and fissures form one of the chief sources of trouble against which users of crucibles have to guard; for although a crucible having defects of this nature may endure for a considerable number of heats, it is nevertheless likely to fail at a critical time.

After receiving heat-treatment for the removal of moisture, crucibles are often placed on a layer of damp sand, or on the comparatively cold furnace floor, and left there for an indefinite length of time before charging. This should not be permitted, because when the temperature of the crucible falls to a point materially below 250 degrees, it will again absorb moisture.

Alligator Cracks

Fine cracks, known as *alligator cracks*, often cover the entire surface of a crucible. These may be caused in a number of ways. Sometimes they are due to heating the crucible with fuel containing too high a percentage of sulphur; or, in oil furnaces, they may be caused by using too little oil or too much steam. It is specially important for the operators thoroughly to understand their work when using an oil furnace, because an excess of air or steam, or an insufficient supply of oil, may give rise to an oxidizing action, whereby a portion of the carbon or graphite is burned out of the crucible wall, leaving the binding clay in a somewhat porous condition; and this action, when it occurs, greatly facilitates the formation of cracks.

When crucibles are stored on the top of a furnace, the melters or furnacemen should make sure that the covers over the furnace openings fit properly. If the furnaceman is careless in this respect the moist gases that are given off when fresh fuel is placed on the fire will escape through the openings to some extent, and they are likely to come in contact with the crucibles, causing alligator cracks to form.

Cracks and fissures are also likely to form if the metal to be melted is not carefully placed in the crucibles. The men usually work rapidly when introducing the ingots, so that the furnaces will not be left open any longer than necessary; and the ingots are often thrown in with a force sufficient to indent the bottoms of the crucibles, or otherwise damage them. An indentation in a crucible, whether caused in this way or in any other way, is quite likely to develop, shortly, into a crack or fracture. The ingots should be introduced carefully and loosely, sufficient time being taken to insure that this is properly done. When a crucible is first filled it is desirable to place as many ingots in it, for the first melting, as practicable; but it is exceedingly important to see that they are not wedged or jammed, because when they are heated they will expand more than the crucible itself, and the walls of the crucible are likely to be cracked in consequence.

When a new crucible is put in service for melting, it should be heated quite slowly for a few runs, and this is *specially important* the first time it is used. After one or two runs it will become vitrified, and the danger from too sudden heating is then materially reduced. It is a good plan to keep on hand a few extra crucibles that have been used before, to avoid loss of time in case an extra crucible is needed on short notice.

A great deal of harm is done by carelessness in handling the tongs and shanks, and the life of a crucible may be seriously shortened in this way. When a tilting furnace is used, as many as 50 heats can often be obtained from a crucible; but if the heating is in furnaces from which the crucibles must be removed by means of tongs, they can be used for only about 15 heats, on an average.

A crucible is soft and plastic at a white heat, and may easily be squeezed out of shape by the pressure exerted upon it when the handles of the tongs are forced together. The walls of the crucible gradually become weakened by treatment of this kind, and eventually, if the crucible is not discarded, a complete rupture will probably occur, with its attendant toll of injuries and burns.

Three styles of tongs are in general use in foundries—one-pronged, two-pronged, and spade tongs. The different styles are designed for various special purposes and operations, but they are sometimes improperly used interchangeably. It is essential to see that the tongs that are used are of the proper shape, and that they fit perfectly from the widest part of the crucible, usually called the *bilge* or *belly*, down to within a few inches of the bottom. They should not extend to the *extreme* bottom, however, because this would make it hard to place the crucible in the shank. On the other hand, if they do not extend down far enough the crucible will be badly squeezed. The proper use of the tongs consists in taking hold of the crucible below the bilge and lifting it in such a way that the least possible pressure is exerted against the crucible walls.

Proper Tongs to Use

One-pronged tongs should be used only for lifting the smaller-sized crucibles, say up to size No. 40. For larger sizes two-pronged tongs should be used. It is not uncommon to see large crucibles, ranging from No. 200 to No. 300, lifted by one-pronged tongs. This practice should be condemned, because when one-pronged tongs are used for lifting a crucible, pressure is exerted against only a single point of contact, namely, at the bottom, and the crucible, when hot and soft, is likely to be cut or ruptured, if it is large and heavy, so that the pressure at the point of support is severe. Serious burns, from the spilling of the molten metal, often result when the lower prong of a two-pronged pair of tongs is cut off, on account of a lack of space between the crucible and the furnace wall, because the crucible is then lifted from above the bilge and tilted. Melters should be cautioned against the practice of driving down the ring of the tongs with a skimmer or other implement, because this is almost sure to cause cracks and fissures in the crucibles.

Reshaping Crucible Tongs

Molten metal is often spilled from crucible in consequence of using tongs that have become bent or otherwise misshapen. It is important to see that the tongs fit the crucibles properly, and that they are also in good condition in every other way. For restoring bent tongs to their proper shape, it is advisable to procure a set of cast iron forms similar in size and general shape to the crucibles that are used in the plant, but slightly larger from the bilge upward. To restore the tongs to their original form it is only necessary to put them in the furnace, raise them to a red heat, clamp them to the proper iron form, and bring them back into shape by means of a heavy hammer. Tongs may be fitted easily and cheaply in this way, and a great saving of time results. If cast iron forms are not provided, the blacksmith cannot be expected to restore the tongs to their correct shape with accuracy; but if iron crucible forms of the proper sizes and shapes are used, and the tongs are fitted to them as here recommended, the likelihood of squeezing and distorting the crucibles will be reduced to a minimum.

Two pairs of tongs, at least, should be provided for each size of crucible, so that if one pair becomes badly bent or worn, the other pair may be placed in service without loss of time.

Furnacemen should make sure that no clinkers or pieces of unburned coal or coke are stuck to the walls of the crucibles when about to grasp them with the tongs, because if the tongs are applied over a clinker the clinker will probably be forced into the crucible, and a rupture may then occur at any moment. It is also important to see that the bottom of the crucible, on the outer surface, is free from clinkers or other adherent substances, so that when the crucible is in the furnace its weight will be evenly distributed, and not concen-

trated at a few projecting spots or regions. It is best to support the crucible by means of a foundation or pedestal, of graphite, fire brick, or other infusible substance, though the fire bed may be made to give a fairly satisfactory support if it is carefully prepared and smoothed.

Buttons in Crucible Bottoms

When a heat has been poured it is important to see that no metal is left in the bottom of the crucible, because when a residual mass or *button* of such metal cools, it contracts at a different rate from the crucible, and serious strains and cracks are likely to result.

Ramming the fuel bed is bad practice, in general, because it is likely to damage the crucibles seriously. If ramming appears to be necessary at special times, the utmost care should be exercised in doing it.

Furnacemen, melters, pourers and helpers, should wear suitable protective clothing, consisting of congress shoes, leggings, and asbestos gloves and aprons. Wooden-soled shoes, or clogs, may be advisable, however, under special conditions. Eye-protectors or goggles, with lenses of colored glass, should be worn to shield the eyes from the glaring brilliance of the molten metal, and to prevent them from being injured by splashes.

If these various recommendations are conscientiously carried out there should be a radical reduction in the number of injuries, a marked extension of the service of the crucibles, and a saving of metal and money. The various precautions that we have suggested are of special importance at the present time because the European war has made it impossible to obtain the best materials for crucible manufacture, and it has, therefore, been necessary to make use of a large amount of native material that is admittedly inferior for this particular purpose. Hence the crucibles that are now being produced in the United States are of a somewhat lower grade, as a class, than the makers would like to turn out, and correspondingly greater care should be taken in handling them.

Navy Revises Steel Casting Specifications

The United States navy department recently has issued new specifications covering the manufacture of steel castings which supersede those issued June 1, 1916. The chemical and physical properties demanded by these specifications are given in the accompanying table.

It will be noted that the sulphur requirements are kept down to 0.05 per cent in all grades of castings except class C, for which no tensile, bending or other physical tests are required, and the sulphur content of this class is increased to 0.07 per cent.

The purposes for which each grade of steel castings is intended are indicated by the following:

Grade A is intended for all important parts subject to crushing stresses or surface wear only, such as hawse pipes, chain pipes, turret roller paths, engine guides, slippers, etc.

Grade B is intended for parts subject to tensile or vibratory stresses, such as stems, sternposts, stern tubes, rudder frames, struts, engine bedplates, cylinders, gun-mount stands, carriages, slides and other parts subject to the shock of recoil.

Grade C is intended for gun mounts, such as brackets, levers, wheels, etc., not subject to shock of recoil, and for commercial fittings where structural strength and separation of water-tight compartments are not involved, such as pipe flanges (other than bulkhead and deck), cagemast fittings, stowage lugs and clips, hinges for doors and hatches where water-tightness is not involved, etc.

Grade D is intended for the same general purpose as grade B, but where greater strength is required with equal ductility.

Grade E is intended for castings for gun yokes, gun mount stands, carriage slides, deck lugs, etc., of large size.

The last specifications of the navy for structural steel work, dated Feb. 1, 1917, demanded not over 0.05 per cent sulphur and phosphorus in all steel castings used in yards and docks and similar work, and limited the sulphur to 0.045 per cent for riveting steel for bridges and buildings.

Steel casting manufacturers are experiencing considerable difficulty in limiting the sulphur content to 0.05 per cent owing to the increase of this element in pig iron due to the high pressure at which this material is being produced and also to the high sulphur content of the coke which now is being furnished to the blast furnaces.

Chemical and Phisycal Requirements of Steel Castings for the Navy Department

	Chemical composition, not over.		Physical Requirements. Minimum tensile strength, pounds per square inch.	Minimum yield point, pounds per square inch.	Minimum Elongation per cent in 2 inches.	Minimum reduction of area, per cent.	Bend test, cold bend not less than — degrees about an inner diameter of 1 inch.
Grade.	Phosphorus, per cent.	Sulphur, per cent.					
F	0.05	0.05	85,000	53,000	22	35	120
A	0.05	0.05	80,000	45 per cent	17	20	90
D	0.05	0.05	70,000	of tensile	22	30	120
B	0.06	0.05	60,000	strength	22	30	120
C	0.06	0.07	.....	obtained.	..	..	...

NOTE—Class F castings may contain nickel or other alloying metals.

How to Prevent Dull Iron

By W. J. Keep

Question.—We manufacture stove plate but our iron has not been sufficiently hot and fluid. Our cupola is lined to 30 inches inside and is equipped with four rectangular tuyeres, 3½ x 8 inches. Our heats average about 6000 pounds. We charge the cupola as follows: Four hundred and fifty pounds of anthracite coal and 110 pounds of coke on the bed, followed by the initial charge of 800 pounds of iron, with subsequent charges of 700 pounds of iron and 90 pounds of coke, the last charge containing 1000 pounds of iron. The blast is furnished by a fan operating at 2600 revolutions per minute at which speed the manufacturer claims it will discharge 3100 cubic feet of air per minute.

Answer.—Your melting ratio is 1 to 5, and, therefore, you are using sufficient fuel to obtain hot iron. If your furnace were equipped with two or three additional tuyeres the amount of air introduced would be considerably increased. If you find that the surface of your coke, when you begin to charge, is not 15 inches higher than the top of your tuyeres, add sufficient fuel to bring it to this height. You can reduce the subsequent charges to compensate for the additional fuel added on the bed. Ascertain the weight of the bed as described, and each subsequent charge should consist of 700 pounds of iron and 70 pounds of coke. We do not understand why you use anthracite coal on the bed since coke is a much better fuel and you can depend upon it to hold up the iron charges.

In one patented method of coating iron or steel with copper, a hollow ingot of the latter metal is first made by filling up a mold and the space left vacant is then filled with molten steel or iron, yielding a compound ingot which may be rolled or drawn.

Modern Methods of Gating Malleable Castings

A Study of the Problems Arising from the Action of Malleable Iron in Cooling Assists in Determining Correct Practice

By A M Fulton

CORRECTLY gating a malleable iron casting is just as important as securing a proper mixture of iron, and should have as much thought devoted to it as to any other feature connected with making the mold or pouring the metal. Irregular sections and sections joining at righ angles prevail to a large extent in malleable castings used in railroad car and heavy construction work. This condition causes an unequal cooling which creates shrinkage and checks at the heavy or adjoining sections. These conditions must be met by the foundrymen, and some manufacturers have made a big error in the past by overlooking this important feature; in many cases they were not absolutely sure that all shrinkage was eliminated. In recent years this difficulty has been eliminated to a very large extent, and today malleable iron is universally recognized as a valuable metal in construction work.

Many patterns are condemned if the loss of castings is above normal and the trouble is attributed to the design, it should have been charged up against the gating. Such criticism, for the most part, occurs when the foundry foreman is extremely busy and does not take time to think out his part of the problem.

From a paper read at the Cleveland meeting of the American Foundrymen's Association, Sept. 11 to 15, 1916.

Importance of Gating

Should the order call for sufficient castings, requiring metal patterns, the pattern shop foreman usually proceeds to make and gate the pattern according to his previous experience. But if he is in doubt as to the best location for the gate, this point should be discussed with the foundry foreman. These two departments should work in unison, having in mind the following points:

First, can the casting be fed from the proposed gate, excluding slag and preventing misruns?

Second, should be heavy or unequal part be fed with a riser located at the top of the casting, as shown at Nos. 1 and 2, Fig. 7, or adjoining the heavy section as shown at No. 3, with a gate into a lighter part of the casting where the likelihood of shrinkage would not occur?

Chills Should be Avoided

Also there are times when we have such designs that the shrinkage can best be taken care of by the use of chills. If it is possible to eliminate chills entirely, it is better practice to do so, as the shrink-head takes care of any possible void, while the chill simply drives the shrinkage to a part of the casting where it possibly may do no harm. The use of properly proportioned heads correctly located will yield much better results than can be obtained from chills, and while the remelt will be increased somewhat, nevertheless, satisfactory castings are secured, providing a correct mixture has been used. All shrinkage is absolutely eliminated and there is no fear of "too hot iron" when heads are substituted for chills.

After tentative plans for gating are settled and molding has been started, it sometimes happens that trouble again arises, in which event the foundry foreman must alter his arrangements. A miscalculation may have been made in the location of the gate, or again, it may have been too heavy at the entrance into the casting. Should the former be the case, then a study should be made of the best point to relocate the gate, having in mind the two suggestions made in a preceding paragraph.

The malleable iron foundry is not unlike any other. It requires constant vigilance upon the part of the foremen of the various departments

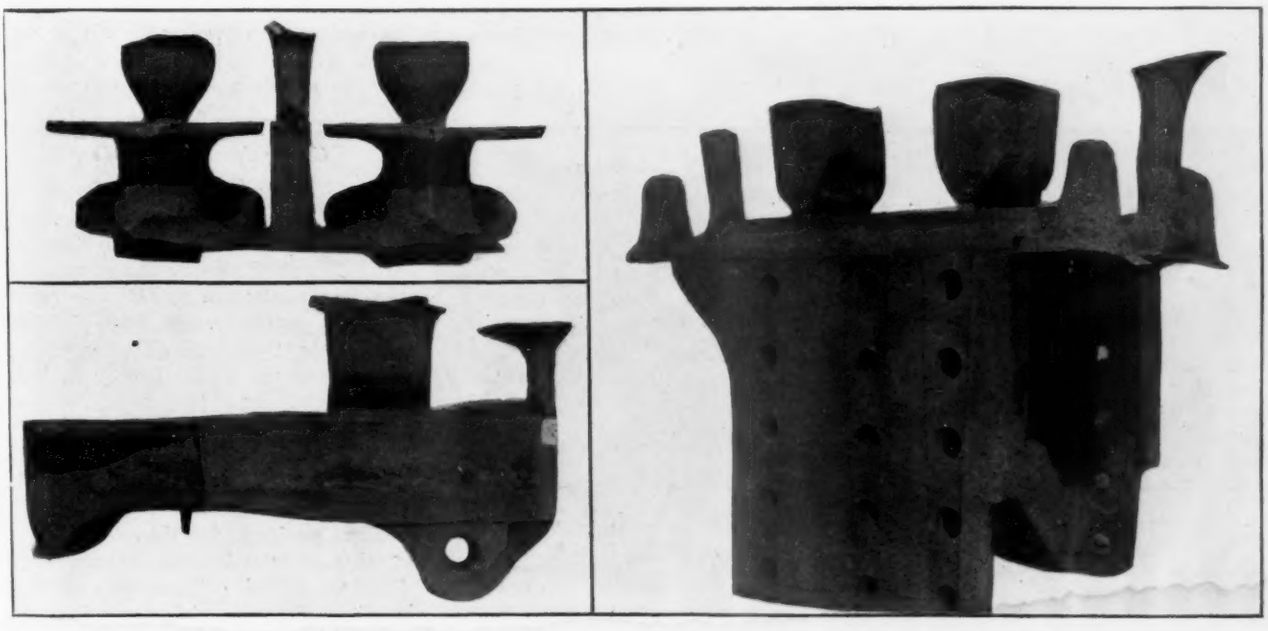


FIG. 1—HINGE-BUTTS WITH HEAVY HEADS
FIG. 2—COLUMN-POST GATED ON THE SIDE

FIG. 3—HEAVY BOLSTER-CENTER FILLER CASTING WITH TWO HEADS

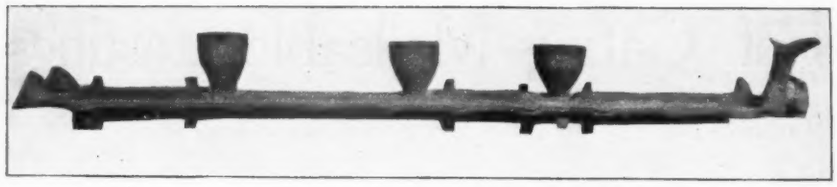


FIG. 4—CHEEK-PLATE WITH THREE FEEDING HEADS

to cope with losses due to shrinkage and to prevent their exceeding a normal amount.

In cases where a large number of small patterns are gated together and you are endeavoring to make as large a mold as possible, due to the light weight of the castings, do not lose sight of the fact that it is important to cast each piece successfully. This is a point that always should be borne in mind. Frequently you hear it said, "This pattern always misruns or shrinks." If too many patterns are gated together, or if they are not arranged correctly, and some pieces misrun or shrink, stop and think out the best method of changing the gate or decreasing the number of patterns to overcome this trouble. Do not continue to make castings in this manner, with high foundry losses, accompanied by increased production cost on the one hand and hidden defects on the other, as it is not only a loss to your business, but a detriment to the malleable industry as a whole.

Cut Out the Shrinkage Defects

Should the castings contain shrinkage defects in cases where the engineer who made the design based his calculations on solid sections, he certainly would be disappointed, as he would not secure the strength counted upon throughout the entire casting, and the piece might fail due to the existence of shrinks. It is essential that absolutely all shrinkage defects be eliminated. Failure to accomplish this end is many times the cause of a change from malleable iron to some other metal.

In order to give the reader a more comprehensive idea of the various methods of feeding castings, a number of diagrams, Fig. 7, are presented showing different designs for heads. A few illustrations of castings, with the gates and heads intact as they came from the sand, also are presented, no attempt being made to show anything special.

In locating a head to feed a casting adequately, it should be placed at a point where the weight of the metal will feed down into the casting, as otherwise the head might rob the casting it was supposed to feed and thus cause shrinkage. In a case of this kind, the head usually should be placed over the heavy section and the gate located at a point where the section is more uniform. For instance, on a flat surface, the use of a design similar to No. 1 or No. 2, Fig. 7, should produce desired results. Should the design of a casting be similar to No. 3, which is a very unequal section, a head of the shape illustrated should feed the casting uniformly. The basin shown below the dotted line keeps the metal in the gate hot and fluid and prevents any possibility of chilling at this point, which would retard the feeding effect. Should we have a section similar to No. 4, Fig. 7, a feed-ball with a basin is satisfactory and in such cases proves very effective in eliminating shrinkage.

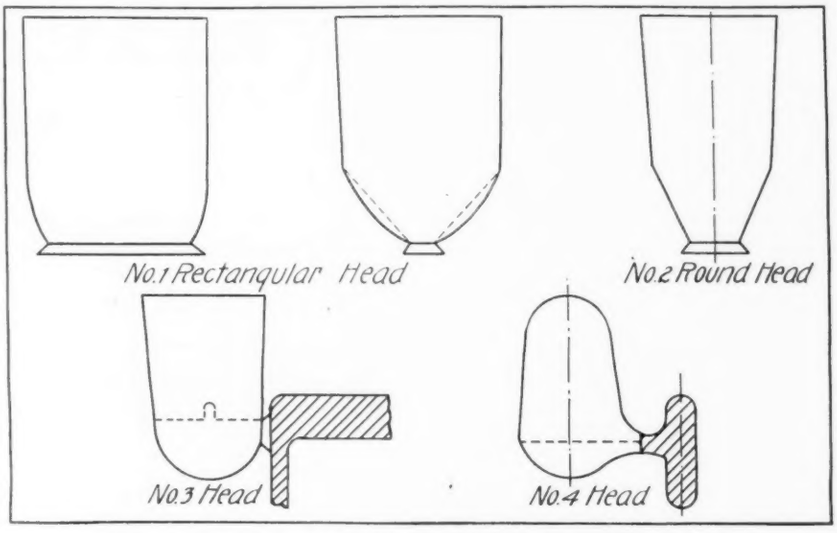


FIG. 7—DIAGRAM SHOWING DIFFERENT TYPES OF HEADS

Gating Irregular Castings

Fig. 8 shows a very irregular sheave wheel casting, in which the sections are far from uniform. The rims are only ⅛-inch thick, the flange to which the head is attached, and the center of the casting range from 5/16 to ⅝-inch in thickness. The casting is gated over the center core with leads sufficiently large to admit the iron freely, yet keeping out the slag. The head in this particular casting is located at the bottom and feeds the casting thoroughly.

The sections in the side-bearing casting shown in Fig. 9 vary from 5/16 to ⅜-inch. There are a large number of angles giving excellent opportunities for shrinkage. Originally this shrinkage was taken care of by

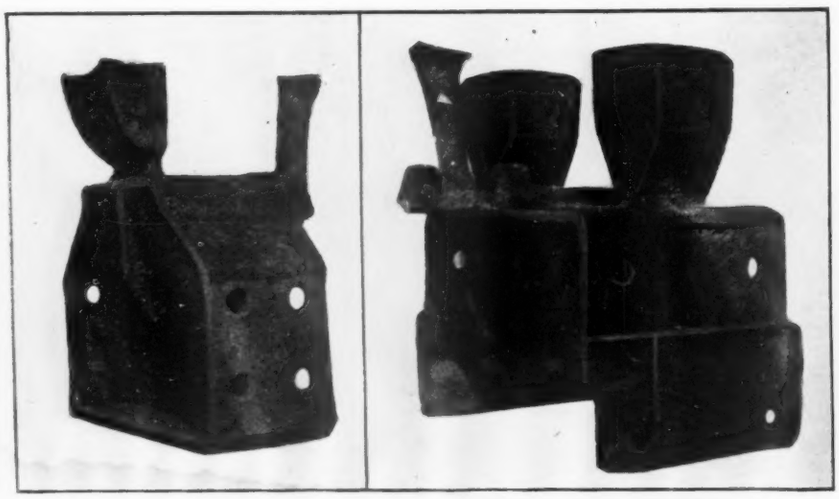


FIG. 5—BACK-STOP WITH A TROUBLESOME WEB

FIG. 6—CENTER-SILL SEPARATOR WITHOUT CHILLS

chills placed in the corners. These chills were eliminated when the head was substituted and an absolutely solid casting was the result. The head is so proportioned that the weight of the metal feeds down into the casting.

The hinge-butt, shown in Fig. 1, is of ½-inch section except at the location of the gate, where it is approximately 1 inch. There is a round head located on each casting which feeds down through the center web, eliminating all shrinkage.

The back-stop shown in Fig. 5 is of ⅜-inch section throughout, with a centrally located web. The construction is such that the center web is pulling against the outside walls during the cooling period. This unequal cooling is taken care of by the head

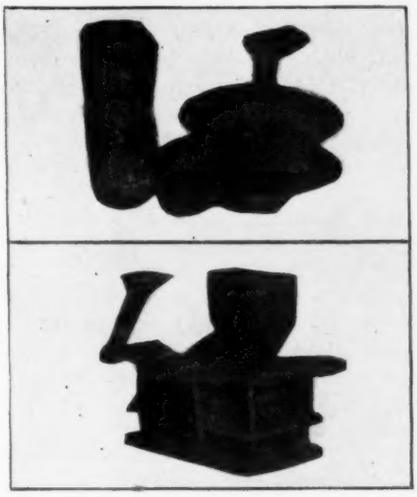


FIG. 8—A MALLEABLE IRON SHEAVE-WHEEL OF IRREGULAR SECTION
FIG. 9 — SIDE-BEARING SHOWING HEAD USED TO ELIMINATE CHILLS

shown in Fig. 5. This head has proven very effective.

In the center-sill separator, shown in Fig. 6, the metal thicknesses vary from ½ to 1 inch. At one time this casting was made with chills located around the center web, the metal being poured from the same gate as now shown in the photograph. The shrinkage was completely removed in this casting by changing from the use of chills to heads, with the elimination of all unsoundness.

The column-post, Fig. 2, is gated on the side opposite from that shown in the illustration with four leads into the mold. The head is located on the flat surface and successfully feeds the casting, eliminating all shrinkage.

The design of the cheek-plate, shown in Fig. 4, is such that it requires three heads to feed it. Also chills are located in each of the three slots. Due to the dimensions of these slots and the necessity for the distance between them being exact, it was decided to mold these castings with dry sand cores in the slots to facilitate the manufacture and reduce variations. The heads feed the casting very successfully.

A bolster-center filler casting is shown in Fig. 3. It will be noticed that this casting is considerably above the average size. The feeding is taken care of by the two heads shown in this illustration. These heads pipe for a considerable depth, which makes it certain that the casting is fed sufficiently.

There are innumerable malleable castings that do not require such measures as have been illustrated in this paper to insure soundness, because their sections are both light and regular, which gives the metal an opportunity to set quickly, thus preventing shrinkage. Such castings can be made successfully by using the style of gate in vogue for many years.

If the malleable founder will take care of his shrinkage by the location of heads so as to feed the casting wherever necessary, he can be sure of success in making heavy pieces with unequal sections. The practice greatly enlarges the field for malleable castings, and permits the engineer to design parts of much greater thickness than was believed possible in the past.

Chilled Iron Balls

By Edgar Allen Custer

In your July issue there is an inquiry as to the best way to make chilled cast-iron balls from 1 to 4 inches in diameter. It is obvious these balls must be cast in a chilling mold and a high chilling iron must be employed. The mold should be made of ordinary foundry iron and for a 4-inch ball should have at least 10 inches of metal outside of any portion that comes in contact with the molten iron. It should be equipped with a trap gate and an ample pouring cup. The accompanying sketches will show the general design.

The greatest difficulty that will be experienced will come from the presence of small dirt or gas holes, and these holes will invariably be near the surface and at the top of the casting. Their presence indicates that the trap is too small and must be enlarged. Small vent holes should be cut in the top of the mold running down to the matrix. These vents should not be more than 1/16 to ⅛ inch, and two will be sufficient.

If this mold is properly designed and operated, it is impossible to make a spongy casting or one that will have

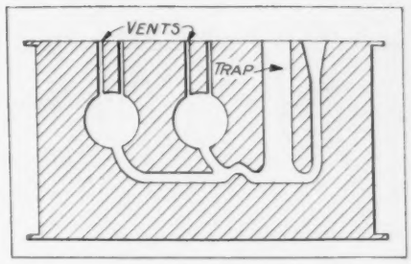


FIG. 1—ARRANGEMENT OF MOLD, GATE AND TRAP

a coarse internal grain. The mold need not be preheated and can be used as fast as the metal can be brought and poured. It will chill as deeply when heated to 400 degrees Fahr. as it will at the room temperature. When the day's work is done, wipe the faces and matrix with a greasy rag. See that all the grease is cleaned off before starting on the next heat. Do a little machine work on the mold and make it so it will open and close easily and surely. Be prepared to pour as much iron in the trap as you pour in the casting. Never put more than two 4-inch balls in a mold.

If these directions are followed, there will be no difficulty in making clean and solid balls. A few pours will be necessary to determine the time the casting must be held in the mold to get the full depth of chill. Hold the first one five minutes and reduce this time by 15-second intervals until the low limit is reached. When the chill comes, it comes in a flash.

According to a British patent, aluminum or any light alloy can be protected from corrosion by sea water, by associating it with another aluminum alloy that is electro-positive to the alloy to be protected. Thus an alloy of aluminum with 5 per cent of zinc, it is claimed, can be used to protect pure aluminum, if used in the form of strips which are electrically contacted with the pure aluminum and submerged in the same medium as the latter metal.

A Norwegian inventor has succeeded in obtaining a patent in that country on a mold facing consisting of 98 per cent fine quartz or silica sand and 2 per cent fireclay.

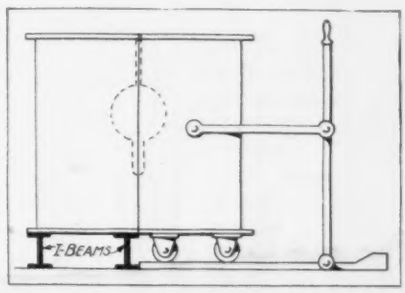


FIG. 2—ELEVATION OF MOLD IN POURING POSITION

Some Test Bar Suggestions For Nonferrous Metal

How Satisfactory Test Bars for Various Alloys May Be Cast —Different Types of Bars Indicate Widely Varying Properties

By Charles Vickers

WE HAVE discovered that no one type of test bar can be used universally, and that it is necessary to change the shape of the bar, and the method of gating and feeding it, to suit the different nonferrous alloys. For some classes of alloys a cast-to-size bar gives the highest tests, while in the case of others it has been necessary to select the test specimen from the lowest cast side of a heavy mass of metal to obtain a section sound enough to afford a suitable test.

It is doubtful whether any test bar is representative of the casting, whether attached as a coupon, or cast from the same heat separately, as the physical properties of the alloy, to such a large extent, depend upon the soundness of the metal, and this in turn upon the success with which the casting is supplied with liquid metal to fill up the vacancies between the crystals which shape themselves as the metal cools and contracts. Thus, it is possible to have a test bar that is sound because properly fed, and a casting to which the test bar is attached that is unsound, because improperly fed. The result is that the test bar is stronger than the casting and, consequently, fails to represent its quality.

The rate of cooling also may greatly influence the strength of the metal; as a general rule, slow cooling has a weakening effect; a test bar attached to a heavy casting will solidify before the casting, although it will be kept liquid by the proximity of the heavy mass of metal sufficiently long to give comparatively low values, but low as the value of the test bar may be, it will be higher than that of the casting to which it was attached. This applies more particularly to heavy castings. In the case of a thin casting it is highly probable that the test bar will give a lower value than the casting itself. This is especially true of aluminum and its alloys, and also applies, to some extent, to the copper and tin series. The reason for this is that a thin casting must be poured with hot metal to insure filling the mold, and it is this hot pouring that is so detrimental to the strength of this class of alloys. The casting, being of thin section, solidifies almost immediately, but the test bar cools more slowly than usual, because it was filled with hotter metal; the result is that its physical values are lower than those of the casting. In the case of the copper-tin alloys, the difference between the casting and the test bar, as a result of hot pouring, may be counteracted largely by properly feeding the bar, but for aluminum alloys this is not possible, with the result that the impaired physical properties of the test bar, due to its attachment to a hot-poured, thin casting, becomes a serious problem for the founder. A large, thin aluminum casting may require pouring at a temperature of not less than 800 degrees Cent. (1472 degrees Fahr.) to run it, while a test bar poured at this temperature will fail in the majority of cases to meet the specifications imposed for ordinary aluminum alloys. The result is that the casting is rejected with ensuing loss to the foundryman. To obtain a fair test in such a case, the test bar should be cast in a dry sand core composed of materials calculated to abstract the heat rapidly from the aluminum and cause the test bar to solidify as quickly as the casting. Every alloy has some peculiarity that influences the physical properties of the bars made therefrom, thereby rendering it difficult, if not impossible, to adopt any one standard method of casting such bars. Thus, the test bars for some alloys give the best results when cast with a longitudinal feeder, as illustrated in the course of this article, while other alloys may be cast more advantageously without the longitudinal feeder. In general, all alloys can be tested from specimens made from cast-to-size bars, and they all can be gated in a similar manner; but the feeders designed to insure the solidity of the casting must be differently disposed to obtain the best results.

The copper-tin alloys are deceiving in their shrinkage property, as it is more liable to be internal than external. In the case of the high shrinkage alloys, such as manganese and aluminum bronze, the shrinkage is external as well as internal and is exhibited on the castings in the form of hollows on the cope-cast parts, and cavities in corners. The finer the grain size of an alloy, the more it will shrink apparently; that is, the more liable the shrinkage will be to show on the outer parts of the castings. Such alloys are difficult for the founder to cast successfully as they require numerous properly-located risers to insure perfect castings. From an engineering point of view, however, the fine-grained alloys are the safest to choose for important parts of machinery as they are less liable to contain concealed defects than the coarse-grained alloys. The crystals in most copper-tin alloys are comparatively large and as the metal solidifies, a network of crystals is formed, shaped to the configuration of the mold. The

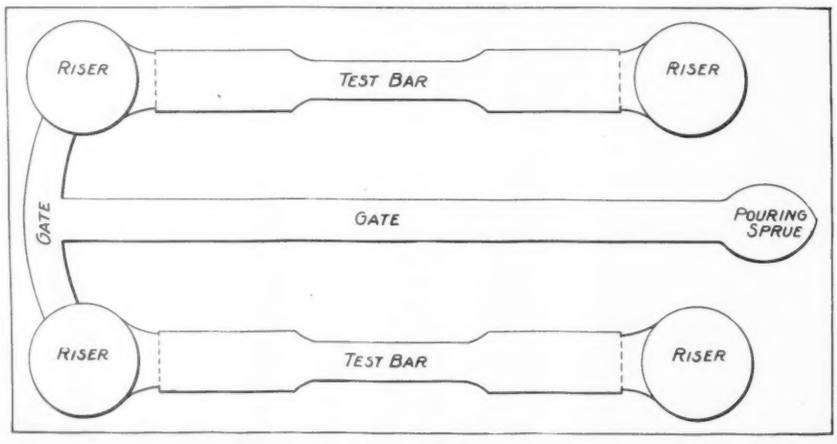
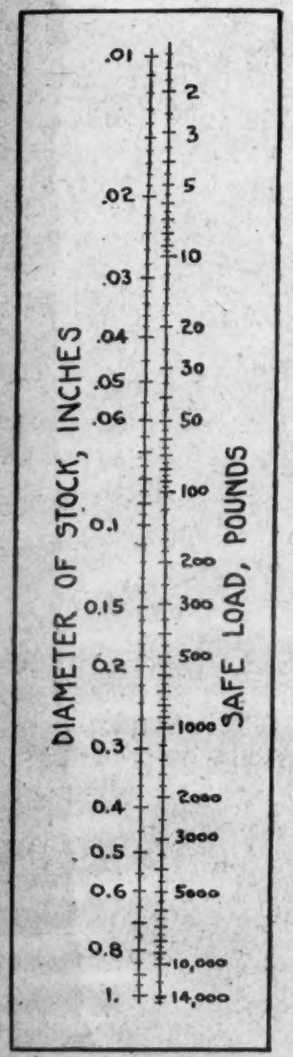


FIG. 1—METHOD OF GATING AND FEEDING ADOPTED WITH GOOD RESULTS FOR ALUMINUM ALLOYS

Payment will be made for all contributions on foundry and pattern shop practice suitable for publication

THE STRENGTH OF CHAINS

By N. G. Near



The accompanying scale for determining the safe strength of chains is based on the formula

$$W = 14{,}000\ d^2$$

where W = total load; d = diameter of stock in inches; and 14,000 represents a fair average constant for open link chain.

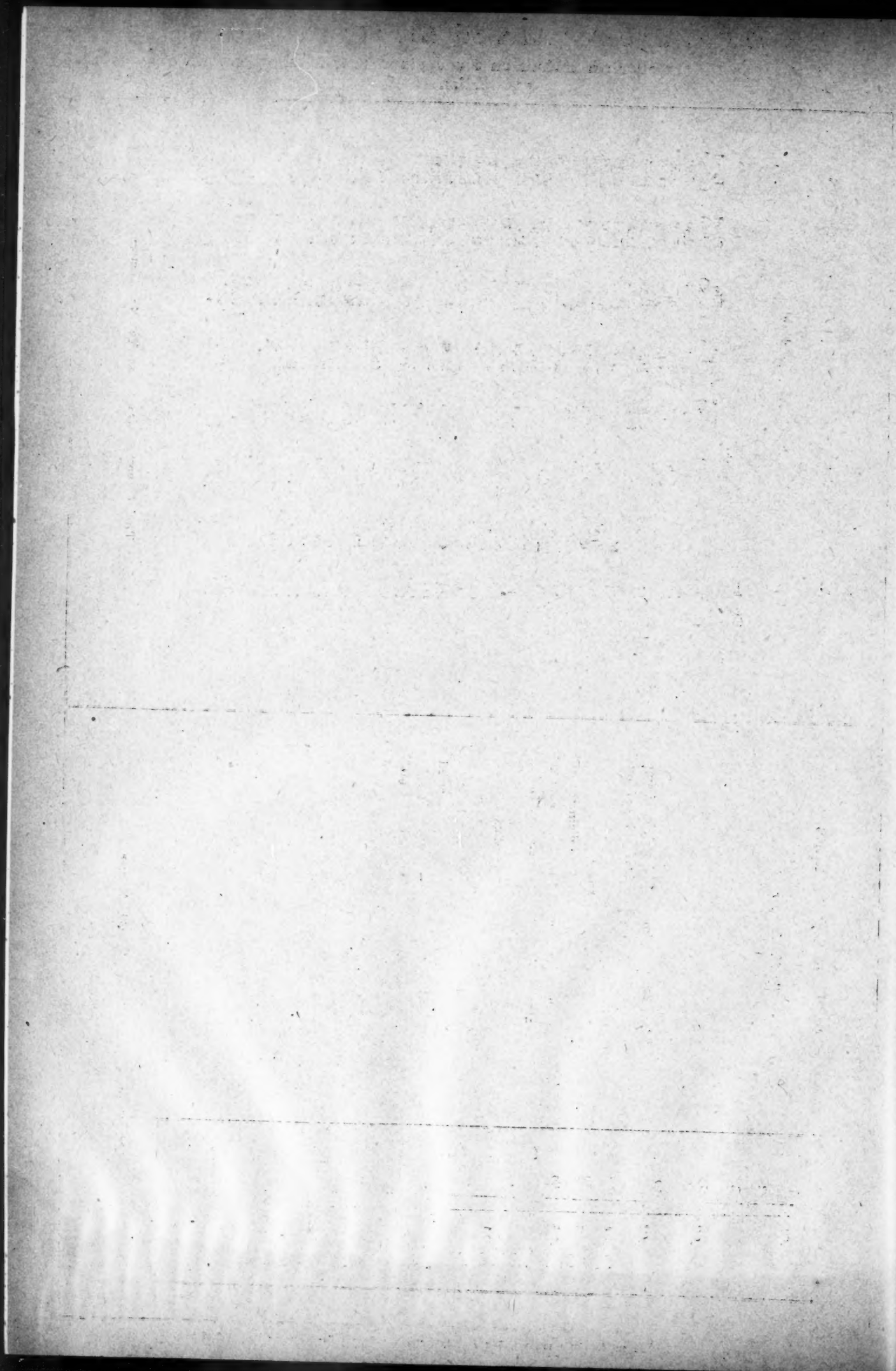
The safe strength of any ordinary stock may be determined by reading from the left-hand column to the right. If it is desired to find the size of stock required to lift a given load, read from right to left. Thus a 5000-pound load requires stock 0.6 inch in diameter. Stock 5/8 inch in diameter, the nearest commercial size, therefore would be used.

Note—This sheet may be cut into two sections, 5 x 7 inches, and may be readily bound in note-book form.

WEIGHT OF SQUARE FOOT OF VARIOUS METALS

By George M. Carson

Thickness of Section (Inches.)	Gray Iron (Lbs.)	Wrought Iron (Lbs.)	Brass (Lbs.)	Copper (Lbs.)	Tin (Lbs.)	Steel (Lbs.)	Lead (Lbs.)
1/16	2.34	2.52	2.7	2.88	2.35	2.59	3.69
1/8	4.68	5.04	5.4	5.76	4.71	5.18	7.38
3/16	7.02	7.56	8.1	8.64	7.07	7.77	11.07
1/4	9.36	10.08	10.8	11.52	9.43	10.36	14.76
5/16	11.70	12.60	13.5	14.40	11.79	12.96	18.45
3/8	14.04	15.12	16.2	17.28	14.14	15.55	22.14
7/16	16.38	17.64	18.9	20.16	16.50	18.14	25.83
1/2	18.72	20.16	21.6	23.04	18.86	20.73	29.52
9/16	21.06	22.68	24.3	25.93	21.22	23.32	33.21
5/8	23.40	25.20	27.0	28.80	23.58	25.92	36.90
11/16	25.74	27.72	29.7	31.68	25.93	28.51	40.59
3/4	28.08	30.24	32.4	34.56	28.29	31.10	44.28
13/16	30.42	32.76	35.1	37.44	30.65	33.69	47.97
7/8	32.76	35.28	37.8	40.32	33.01	36.28	51.66
15/16	35.10	34.80	40.5	43.20	35.37	38.88	55.35
1	37.44	40.32	43.2	46.08	37.72	41.47	59.04
1 1/16	39.78	42.84	45.9	48.96	40.08	44.06	62.73
1 1/8	42.12	45.36	48.6	51.84	42.44	46.65	66.42
1 3/16	44.46	47.88	51.3	54.52	44.80	49.24	70.11
1 1/4	46.80	50.40	54.0	57.60	47.16	51.84	73.80
1 5/16	49.14	52.92	56.7	60.48	49.51	54.43	77.49
1 3/8	51.48	55.44	59.4	63.36	51.87	57.02	81.18
1 7/16	53.82	57.06	62.1	66.24	54.23	59.61	84.87
1 1/2	56.16	60.48	64.8	69.12	56.59	62.20	88.56
1 9/16	58.50	63.00	67.5	72.00	58.95	64.80	92.25
1 5/8	60.84	65.52	70.2	74.88	61.30	67.39	95.94
1 11/16	63.18	68.04	72.9	77.76	63.66	69.98	99.63
1 3/4	65.52	70.56	75.6	80.64	66.02	72.57	103.32
1 13/16	67.86	73.08	78.3	83.52	68.38	75.16	107.01
1 7/8	70.20	75.60	81.0	86.40	70.74	77.76	110.40
1 15/16	72.54	78.12	83.7	89.28	73.09	80.35	114.39
2	74.88	80.64	86.4	92.16	75.45	82.94	118.08
2 1/4	84.24	90.72	97.2	103.68	84.88	93.31	132.84
2 1/2	93.60	100.80	108.0	115.20	94.32	103.68	147.60
3	112.32	120.96	129.6	138.24	113.18	124.41	177.12



crystals retain that shape when solid, unless the casting is of very heavy section, when the crust may sink and form a hollow. With castings of ordinary thickness, however, the exterior maintains the shape of the mold, because the solidified skin is supported by the large crystal formation while part of the interior is still molten, and as this solidifies, shrinkage occurs with the result that the casting may be satisfactory externally, but has shrinkage defects inside. This is due to the fact that after the formation of the skeleton of crystals, the metal inside continues to shrink as the various alloys richer in tin until all the liquid metal is consumed and no more is available to fill the vacancies that exist between the crystals at the center of the casting. The result is internal shrinkage which in flat castings, ½ to ¾-inch in thickness, is often manifested as a split and appears in the form of lemon-colored spots in castings of heavier section. Microscopic examination indicates that the lemon-colored spots consist of the same crystalline formation as the balance of the alloy, but minus the blue eutectic. Where the latter should have been there are voids, the crystals being attached to each other only at their more prominent angles. A test bar, therefore, taken from a portion of metal exhibiting these lemon-colored spots is comparatively weak, as the crystals of the metal, having slight contact with each other, are easily pulled apart. This is responsible for a large majority of the failures of castings to withstand hydraulic pressure. It also explains the popular belief that in the skin of a bronze casting lies its strength, for if we machine off the outer portion of a bronze bar, we remove the part that has been supplied with sufficient eutectic to firmly cement the crystals of the structure together.

Effect of Gating on Test Bars

A test bar of any of the copper-tin alloys, in the majority of cases, bears a most striking resemblance to a stick of elder wood so far as its internal structure is concerned, provided there has been failure to supply its central part with eutectic from some external source. This condition can be called upon to prevail in all cases where the test bars are gated or fed from the ends, because the central portions of the bars solidify too rapidly to permit of proper feeding with fluid metal to balance the shrinkage of the interior. For this reason, test bars of the copper-tin and copper-zinc series, that are gated with a fin gate possess much higher physical values than bars that are end-gated.

Table I

Physical Properties of Manganese Bronze From Cast-to-Size Test Bars

Heat No.	Ultimate strength, per square inch.	Yield point, pounds per square inch.	Elongation per cent. in 2 inches.	Reduction of area, per cent.	Remarks.
161	84,600	35,900	20.5	19.8	Two cast-to-size test bars with feeders. Tests poured from first heat of new metal immediately after proper pouring temperature was reached. New copper was used and Western spelter.
	83,100	33,300	23.5	23.7	
162	84,600	33,000	20.5	19.6	Two test bars cast-to-size made as nearly as possible the same as No. 161. The copper was 50 per cent new and 50 per cent scrap copper used entirely.
	82,700	32,100	20.0	19.4	
163	78,000	21,100	23.5	21.6	Two test bars cast-to-size made same as two previous heats, but scrap copper used entirely.
	78,300	22,500	25.0	24.3	

Analysis, approximate: Copper, 57.73 per cent; zinc, 40.45 per cent; manganese, 0.08 per cent; aluminum, 0.64 per cent; iron, 1.07 per cent; tin, 0.03 per cent; lead included with the zinc.

Test bars of aluminum bronze and also the light alloys of aluminum give the highest values when they are end-gated and are fed also with risers on the ends of the grips, as shown in the plan, Fig. 1. This is because all aluminum alloys are weakened more by slow cooling than by insufficient feeding.

The phenomenon attending the solidification of metals from a liquid to a solid state is a subject for study rich in possibilities for all who are interested in the casting of nonferrous metals and alloys. The smaller the crystals of an alloy, that is, the finer the grain, the easier it is to control its internal shrinkage and thereby secure castings possessing the maximum strength inherent in the alloy. As the crystals shape in a coarsely crystalline metal, they form a network, or project angles into the still fluid portion of the metal, and thus offer an obstruction to the passage of the more fusible portions of the alloy that makes it extremely difficult to feed metal to fill all interstices and thereby insure a sound casting. We frequently find that test bars, even when connected to a heavy, longitudinal feeder by a thick gate, when broken, display a small, unsound spot at the center, due to the lack of pressure and cool pouring.

Difficulty of Feeding

The difficulty of intercrystalline feeding has an important bearing upon the production of all bronze castings that are subjected to pressure, and this problem should receive careful consideration by every engineer when designing cast bronze machine parts that will be subjected to the pressure of liquids or gases. The only way by which intercrystalline feeding can be carried out with hope of success is by means of the hydrostatic pressure applied by sprues and risers of more than ordinary height, and sufficiently large in diameter to pre-

Table II

Physical Properties of Gun Metal as Shown by Differently Cast Test Bars

	A	B	C	D	E
Yield point, pounds per square inch...	19,700	14,700	20,100	21,000	22,600
Ultimate strength, pounds per square inch	35,100	18,700	36,900	24,400	50,000
Elongation, per cent in 2 inches.....	9.3	4.5	21.0	5.8	40.0
Reduction of area, per cent.....	9.0	1.0	17.2	2.0	34.2

HOW THE BARS WERE CAST

Bar A.—Machined from 1 inch round bar; cast horizontally with slight incline; gated at lower end of flask; sprue at high end and feeder on end of bar.

Bar B.—Machined from 1 inch square bar; cast horizontally with a 2 x 1-inch riser on center of bar where turned to 0.505 inch and gated at end farthest from sprue.

Bar C.—Machined from 1 inch square bar with 2 x 1-inch riser on center; gated on end and metal run directly into casting.

Bar D.—Machined from 1 inch square bar; cast vertically and drop-gated.

Bar E.—Cast-to-size bar with longitudinal feeder as illustrated in Fig. 2.

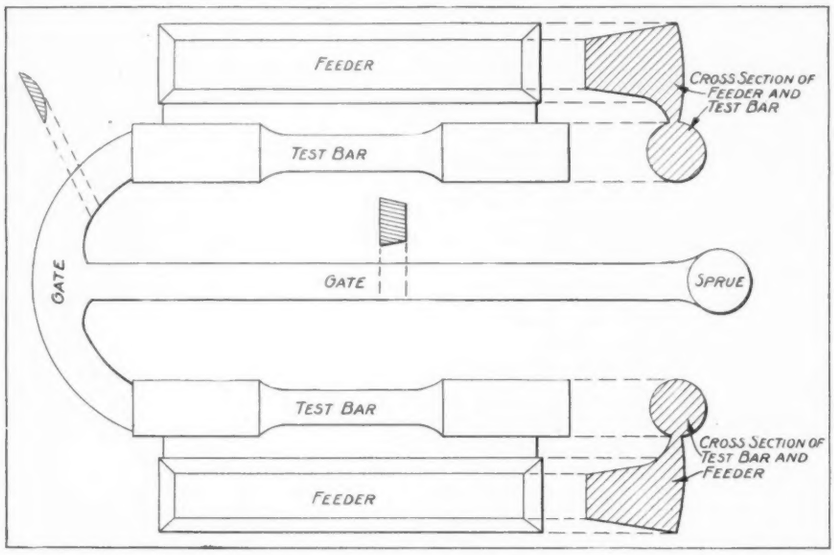


FIG. 2—A METHOD OF GATING AND FEEDING TEST BARS FOR MANGANESE BRONZE AND GUN METALS

vent the metal they contain from congealing before the casting cools. The drop-pouring process of casting is an example of this method of making bronze castings for pressure work. By this method, as practiced by one manufacturer, the height of the sprues and risers is 2 feet above the mold, which puts the casting under much greater pressure than if molded in the ordinary manner. The result is that 98 per cent of the castings are sound, whereas by the pursuit of ordinary foundry methods, the reverse is largely true.

Explanation of Pores in Bronze

There is another explanation of the pores or interstices between the crystals of cast bronze than the one here advanced. It assumes that their presence is due to the dissimilar contraction of the various copper-tin alloys formed during the freezing of the casting, or to the volume changes that are supposed to accompany the decomposition of the *beta* into the *alpha* and *delta* constituents as a result of the slow-cooling of the alloy. There are many difficulties connected with the casting of these alloys, however, that are better explained by attributing their lack of strength and porosity to an insufficient amount of cementing material between the crystals due to improper feeding Therefore, it will do no harm to give due consideration to this theory when important castings are to be made, and to adopt all precautions that experience may suggest to insure that all heavy sections of the casting have the opportunity to draw on risers or feeders of sufficient volume to eliminate the possibility of intercrystalline porosity to as great an extent as possible.

In making separately-cast test bars of such an alloy as manganese bronze, it is the customary practice to cast them on a mass of metal known as a *keel block*. This block is illustrated at *B*, Fig. 4; its minimum size is about 4½ inches long, 3 inches wide and 4 inches thick. The coupons are cast on either side and one on the bottom, each 4½ inches long and 1 inch square. The casting and gate will weigh approximately 50 pounds. This is the minimum weight, as the grips are so short they must be threaded; therefore, if plain grips are preferred the keel block must be made longer, and it will require still more metal to make the castings. At *C*, Fig. 4, is shown a slightly different form of keel block that requires less metal than the former type and is easier to mold in cases where this type of bar is preferred. This pattern can be made from a piece of pine, 2 x 4 inches, and it carries two test coupons on the bottom, each 1 inch square, and as long as it may be decided to make the test bars. If this coupon block is poured on an incline with the gate running to the lowest point and the sprue placed at the highest point, with a riser 3 inches in diameter at the highest end of the casting, as shown in Fig. 4, two test bars will be obtained that will give satisfactory tests for manganese bronze.

A much better form of test bar is illustrated in plan, in Fig. 2, and is adapted equally well for gun metals or for manganese bronze. It is a modification of the fin gate principle, and was devised by the writer to permit of making reliable, comparative tests of manganese bronze with a minimum use of metal, and without the necessity for machining the test specimens. When the test specimens are attached to keel blocks, as shown in Fig. 4, experimental work on manganese bronze alloys is expensive. After the casting is obtained the coupons are cut from the block, which is followed by the operation of machining them from 1 inch square to the standard test bar, 0.505 inch at the center and ¾-inch at the grips. Thus an immense amount of work is necessary to obtain a little test bar.

Simple Test Bars

As previously stated, the method of making test bars, illustrated in Fig. 2, can be practiced either with manganese bronze or any of the copper-tin alloys, with equally good results. It will be noted that the castings are gated at the end farthest from the sprue. The metal, therefore, passes down a long gate of rectangular section with tapered sides, set in the drag of the mold, and being divided at the end, runs into each casting at their ends. After partially filling the test bars, it flows through the longitudinal gate into the feeder located entirely in the cope next to each casting. Thus any dross that survives the passage down the long runner and enters the test bar molds, has a good chance of being floated into the feeder where it does no harm. The gate connecting the test bar and the feeder should be about 3/16-inch thick at its junction with the test bar, and this thickness should rapidly increase to its point

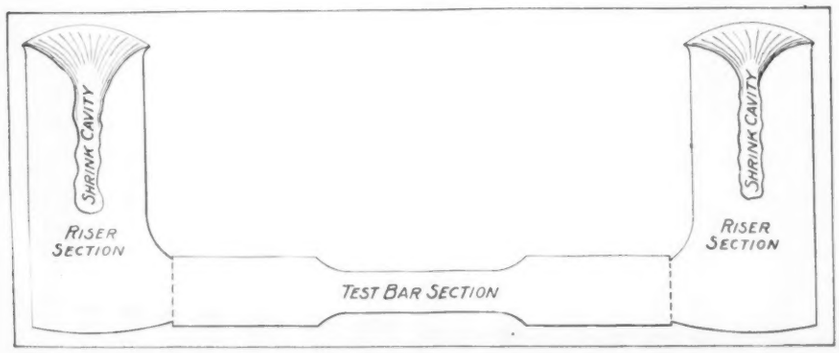


FIG. 3—LONGITUDINAL SECTION THROUGH A TEST BAR OF ALUMINUM BRONZE, SHOWING ITS RISERS

of junction with the feeder. A flat fin gate of uniform section would be worthless and must be avoided, as it would promptly freeze and shut-off the flow of metal from the feeder to the casting. The riser is merely an elongated mass of metal of rectangular section that parallels the test bars as shown in Fig. 2, and while the illustration shows only one test bar for each feeder, in practice, one feeder will serve two test bars; one on either side of the feeder. The feeder should approximate a width of 1½ inches at the bottom, tapering to 1 inch at the top, thus allowing plenty of draft to facilitate molding. The length of the feeder will be governed by that of the test bars, and the latter will vary according as to the grips desired. The feeder can be about 1 inch shorter than the test bar.

A little more work is required to prepare fin-gated test bars for pulling than those gated on the ends, but it is not difficult to detach the castings, especially when a power saw is available. The bars are sawed off in line with the grips and the section of gate left along the thin portion of the bar is carefully ground, avoiding cutting into the bar, after which the latter is finished with a file. This method of making test bars requires a minimum amount of metal, as a heat of about 10 kilograms will pour one mold giving either two or four test bars, and such a heat can be handled easily by one man.

The tests recorded in Table 1 cover three heats of manganese bronze made from test bars that were cast in the manner outlined. In comparing test bars cast this way with bars machined from keel blocks it was found that the difference in physical properties as obtained by the two kinds of bars was so slight as to be unimportant. For research work especially, this type of test bar can be recommended for manganese bronze; it is also valuable in regular foundry practice as it enables quick control tests to be made of this alloy.

The following will illustrate the value of this type of test bar particularly in connection with research work. An alloy was made to conform to a new formula and in the first test the copper was melted together with a hardening alloy that would carry into the bronze all the desired constituents except the zinc, the latter being added in the form of spelter after the bath of copper and hardener was thoroughly liquid, which occurred without superheat. After the addition of the zinc which amounted to 41 per cent of the mixture, the alloy was stirred well. Every precaution was taken to prevent the bronze from flaring strongly, and as soon as the alloy showed zinc flares when its surface was disturbed, it was removed from the fire and was poured into the mold. The physical properties of the first heat follow:

Ultimate strength, pounds per square inch	88,400	90,600
Elongation per cent in 2 inches	20	25
Reduction of area, per cent	26.8	24.9

After these tests had been obtained the alloy was remelted, flared for 15 minutes and recast into test bars with the following results:

Ultimate strength, pounds per square inch	89,900	90,000
Elongation, per cent in 2 inches	26	27
Reduction of area, per cent	26.8	24.9

The foregoing physical properties would indicate that the formula, as devised, was excellent as determined by this economical method of making the test bars.

Tests of a Copper-Tin Alloy

In Table II the results are given of a number of tests of a copper-tin alloy made on bars differently shaped and cast, compared with bars cast with the longitudinal feeder. The alloy consisted of copper, 90 per cent and tin, 10 per cent in all of the tests. It will be noted that bars *B* and *D* gave very poor values, and there is little doubt that the difficulty with all the bars except *E*, was due to unsoundness at the core which was accentuated by the fact that all the strong outer skin had been eliminated by the machine work necessary to turn them. The 2 x 1-inch riser that was placed on the horizontally-cast square bars was too small to do much feeding as it solidified more quickly than the bar to which it was attached. In the case of bar *C*, the feeder had a chance to function better, as the metal was poured directly into the molds, instead of having to run to the bottom and then back up. When the metal is poured on the cool side, even the fin feeder on cast-to-size bars will not entirely obviate unsoundness of the center, because the metal sets before the eutectic can soak through to the core. This unsoundness is exhibited as a yellow center which materially affects the strength of the bars.

The following test of an alloy of copper, 88 per cent; tin, 10 per cent and zinc, 2 per cent, was much lower than it should have been for this alloy and this method of casting the bars, owing to the yellow centers. The physical properties follow:

Ultimate strength, pounds per square inch	44,600	45,000
Yield point, pounds per sq. in.	23,600	21,800
Elongation, per cent in 2 inches	23	23
Reduction of area, per cent	26.8	24.9

An alloy of copper, 88 per cent; tin, 10 per cent and lead, 2 per cent,

Table III

Difference in Physical Properties of Gun Metal When Cooled Rapidly and Slowly

Alloy, "Composition G.":—Copper, 87 to 89 per cent; tin, 9 to 11 per cent; zinc, 1 to 3 per cent, and phosphorous, 0.20 per cent.

	Heat No. 171.		Heat No. 172.		Heat No. 173.
Ultimate strength, pounds per square inch	43,200	45,300	44,200	47,300	32,400
Yield point, pounds per square inch	22,100	21,400	21,200	21,600	18,000
Elongation, per cent in 2 inches	27.0	33.5	29.0	36.5	20.5
Reduction of area, per cent	33.0	32.8	31.8	33.0	21.4

Heats Nos. 171 and 172 were from cast-to-size bars as shown in Fig. 2. Heat No. 173 was cast into a keel block, such as used for manganese bronze and illustrated in Fig. 3.

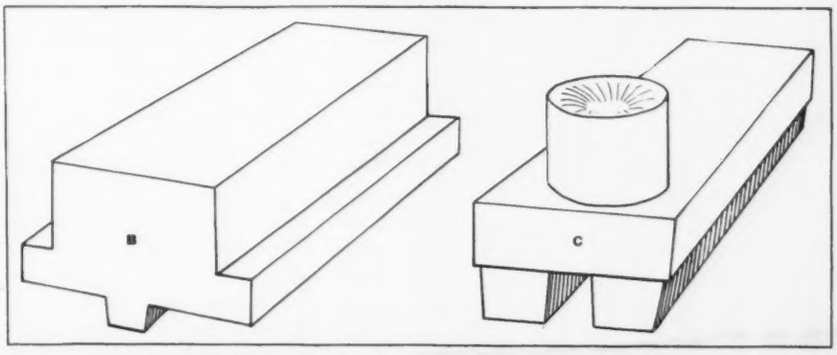


FIG. 4—TWO TYPES OF KEEL BLOCKS FOR OBTAINING MANGANESE BRONZE TEST BARS

with yellow centers, gave the following values:

Ultimate strength, pounds per square inch	42,200	41,100
Yield point, pounds per square inch	24,500	23,600
Elongation of 2 inches, per cent	17.5	17.5
Reduction of area, per cent	16.1	19.7

Where a very exact test is required and it is advisable to use machined test bars, the longitudinal feeder system can be relied upon to give excellent results. In the following tests a round bar was used for patterns. Its diameter was ¾-inch throughout, and it was cast with the side feeder and longitudinal gate, and was afterwards machined to proper standard size. The alloy consisted of copper, 80 per cent; tin, 5 per cent; lead, 3 per cent, and zinc, 2 per cent. The bars had the following values:

Ultimate strength, pounds per square inch	35,000	36,000
Yield point, pounds per square inch	16,800	17,000
Elongation, per cent in 2 inches	30.5	33.0
Reduction of area, per cent	28.2	28.3

In Table III are given tests which illustrate the effect of slowly cooling the copper-tin alloys. In all the tests the bars were sound to their centers. Heats Nos. 171 and 172 were cast-to-size bars and heat No. 173 was a keel block, the coupons from which were machined to size. It will be noted that the weakest bar of the cast-to-size series is 25 per cent stronger than that taken from the keel block, and it possesses 26 per cent greater elongation.

The tests given emphasize the fact that if it is necessary, in order to obtain the highest physical properties of the metal in a test bar, to connect the latter to a comparatively heavy feeder and also to insure a rapid rate of cooling, the judicious use of feeders is equally essential to obtain soundness in any important casting. When the latter is of heavy section and high physical properties are demanded, efforts must be directed to hasten its solidification by the incorporation in the mold structure of substances of higher heat conductivity than ordinary molding sands. This feature has received little attention in the manufacture of bronze castings, although it is practiced in casting aluminum alloys. The importance of insuring the more rapid solidification of the metal than is obtained in an all-sand mold has long been recognized by ironfounders, so that it is not unusual for large iron castings to be made in molds that abstract the heat from the molten iron more rapidly than is possible with sand alone.

In Fig. 1 is illustrated a method of casting test bars that has proved its value for aluminum alloys, including aluminum bronze. For such alloys it has been found that the proximity of the heavy side feeder retards the cooling of the test bars to such an extent that its influence in promoting solidity is more than offset by the slow cooling its presence entails; therefore, better results are obtained by placing risers on the ends of the grips as shown. In Fig. 3 is illustrated a cross-section through an aluminum bronze test bar. The risers, it will be noted, are massive compared to the casting, and contain deep shrinkage cavities which is characteristic of aluminum bronze when sound. Whenever this alloy is permitted to cool slowly its structure is changed and it loses all its more valuable physical properties. Therefore, it has been found that a different disposition of the feeders is required than in manganese bronze and the gunmetal alloys.

PROBLEMS OF THE BRASS FOUNDER

What To Do and How To Do It

Core Sand for Brass

We would like to have a core sand mixture for brass castings which will satisfactorily resist the metal. We generally use an oil sand mixture, but have tried core compounds and resin with unsatisfactory results.

If the castings are heavy, that is, if the cores are surrounded by one or more inches of metal, an excellent core can be formed by silica, or any good, refractory sharp-sand bonded with linseed oil. The core should be baked to a nice brown color as is usual, and when cold, should be coated with a good grade of plumbago mixed to a paste with weak molasses water. This paste should be rubbed onto the core, and should be given a polish like a stove. The core should then be warmed to drive off all the moisture. The metal will not penetrate such a core, because all the little spaces between the grains of sand are filled with the plumbago.

On the other hand, if the castings come rough inside and cores are small and the castings light, like plumbers' work, the cores are being made with too large a proportion of sharp sand, and the mixture should be changed to embody more molding sand in order to make a smooth core that the metal cannot penetrate. The cores should also be well rammed to produce a firm, smooth surface. The sand can be bonded with either rosin, oil or flour, as most convenient, as the bonding agent has nothing to do with the metal penetrating the core. This inconvenience is due to failure to protect the core with plumbago in the case of thick castings, and to using too coarse a sand in the case of small castings.

Mixture for White Metal Patterns

Will you kindly furnish us with a mixture for white metal patterns?

An excellent mixture for white metal patterns follows: Tin, 50 per cent, and zinc, 50 per cent. Where the minimum amount of shrinkage is required the formula is modified slightly as follows: Tin, 50 per cent; zinc, 49 per cent, and bismuth, 1 per cent.

Plaster of Paris in the Brass Foundry

Will you kindly let me know how plaster of paris should be treated to permit of its use for making bronze castings?

Plaster of paris is too expensive to permit of its use in the production of ordinary brass castings. This is not due so much to the cost of the plaster as to the expense of treating the molds to prepare them for the molten bronze. To make the molds, plaster is mixed with red brick dust in the proportion of two parts of dust to one part of plaster. Carborundum fire sand also can be used in place of the brick dust, as well as a number of other substances which possess refractory properties and are sufficiently open to permit the passage of gases. This method only is employed in making statuary bronze by the lost wax process which involves the making of a mold by casting a self-hardening refractory substance around a wax model and when the mold has hardened, the wax is melted out. The mold then is gradually

heated until an approximate temperature of 1000 degrees Cent. is reached, when all of the moisture is driven out. The metal is poured while the mold is hot. The plaster of paris is the medium that binds the mold and when the latter is finished the plaster must be thoroughly dried, as otherwise the metal will not lie quiet in the mold.

Strong Aluminum Alloys

We read with much interest the Data Sheet published in the June issue of THE FOUNDRY, *entitled, "Strong Aluminum Alloys." We cannot understand, however, that no tin appears in the last analysis when 3¾ pounds were used in the hardener. We would like to get an alloy suitable for making pattern plates.*

The formula for the hardener referred to consists of 3¾ pounds of tin plate, no mention being made of tin. Tin plate is steel or iron coated with tin and it is employed to add iron to alloys, because the coating of tin protects the iron from oxidation while it is being introduced into the balance of the molten alloy. The amount of tin added in this way is negligible. This alloy is not suitable for match-plates as it is too soft. A more suitable alloy follows: Aluminum, 90 per cent; tin, 2 per cent, and copper, 8 per cent.

Castings Subjected to Water Pressure

We would like to have your suggestions for a bronze mixture that will withstand water pressure. We have experienced considerable difficulty with the following: Copper, 40 pounds; tin, 4 pounds; lead, 1 pound and 30 per cent manganese-copper, ½ pound. Out of four castings we have made, three developed leaks when tested. Subsequently, we added 14 pounds of yellow brass punchings, but without success.

Figured in percentages, the formula you have been using is approximately as follows: Copper, 88 per cent; tin, 8.8 per cent; lead, 2.2 per cent and manganese-copper, 1 per cent. As the composition of the 14 pounds of yellow brass added to the original mixture is unknown, it is impossible to compute how much zinc was added, but undoubtedly this was sufficient to disturb the alloy and make the castings leak.

We suggest an entire change of mixture as follows: Copper, 88 per cent; tin, 4 per cent; zinc, 6 per cent; lead, 2 per cent and omit the manganese-copper. This mixture has been used successfully for castings subjected to water pressure in government work, having successfully supplanted the 88-10-2 alloy for some castings. We believe that permission can be obtained to use this alloy and we suggest that in melting the mixture a flux be used in addition to the charcoal.

Remedying Brittle Bushings and Gear Blanks

The castings for bushings and gear blanks which we are making are brittle and lack uniformity. We melt in an open-flame furnace, test the temperature by pyrometer and pour at approximately 1960 degrees Fahr. We have experimented with deoxidizers and fluxes without satisfactory results. For bearings, we use an alloy consisting of copper, 85 per cent; tin, 10 per cent; zinc, 3 per cent and lead, 2 per cent. For other castings the mixtures consist of copper, 83 to 84 per cent; tin, 6 per cent; lead, 8 to 9 per cent, and zinc, 0.5 per cent. This alloy consists of one-half ingot metal and one-half turnings from our machine shop. The tensile strength of this alloy is 22,000 pounds per square inch, with an elongation of 8 per cent.

It is probable that better results will be obtained by changing the mixture slightly, and for bearings we recommend the following: Copper, 84.75 per cent; phosphor copper, 0.25 per cent; tin, 10 per cent, and lead, 5 per cent. For the other castings, figure the proportion of scrap so they work out approximately as follows Copper, 87 per cent; tin, 6 per cent; zinc, 5 per cent, and lead, 2 per cent. Judging from the low tensile strength, we are inclined to believe that your difficulty might be traced to the method of melting, but we are unable to guess what this may be. It is good practice to make up for the zinc lost by volatilization. Also, it is necessary to use a flux, but more than 6 ounces per 100 pounds of metal must be used. A sufficient amount should be charged to cover the surface of the metal to protect it from the products of combustion. This is the only province of the flux as it consists of fluorides, oxides and carbonates which cannot be reduced by the molten metals.

How to Prevent Pin Holes in Brass Castings

We are experiencing considerable trouble in producing satisfactory brass castings for plumbers' use. Our scrap is carefully selected, the metal being thoroughly covered with salt and fluxes throughout the melting operation, but notwithstanding this, the castings show pin holes when polished. These pin holes are near the gates and often look like slag or dirty metal.

We only can hazard a guess as to the cause of this difficulty. If it is due to the pin holes, these may be produced by pouring very hot metal into poorly-vented molds, molds rammed too hard, or molds made of sand that is too close which will not allow the vents to come off freely. Then again, it may be due to burnt metal and since you are using scrap which may not be first-class material, the difficulty might be traced to this source. Furthermore, the imperfections may not be pin holes, but probably might be due to zinc oxide which gets into the castings because the molds are not properly gated for this metal and perhaps the latter is being poured too slowly. This defect may be traced to almost a limitless number of other causes and we suggest that you definitely determine whether the trouble is really due to pin holes or to dirt in the metal. If due to the former, do not pour any hotter than necessary to run the castings, vent the molds with a fine knitting needle and do not ram them as hard as formerly. If the metal contains no aluminum, try the addition of 2 ounces per 100 pounds, pouring when the metal no longer smokes. Sheet brass clippings are satisfactory for this work and it is evident that if your trouble cannot be traced to the scrap, then it must be due to your method of melting or pouring. We believe that aluminum can be used in this mixture and if this is possble, it will correct all of the faults except one. This involves the dross which can be kept out by proper gating.

If aluminum cannot be used, pour the molds with sufficient force to keep the pouring heads full, even if some of the metal spills when they are filled. Exercise care to have the molds so well vented that when the gases come off, they will explode when the red-hot skimmer is inserted underneath the bottom boards.

Mixture for Oxyacetylene Torch Castings

Owing to the difficulty of securing brass castings, we are compelled to make those used for the oxy-acetylene torches which we manufacture. These castings are exposed to high temperatures and weigh approximately 4 ounces to 2 pounds. We are contemplating using natural gas for fuel and we have figured on building a furnace by placing a 20-pound crucible inside of a 50-pound pot and centering the heating torch underneath the bottom of the large pot. We would like to have you suggest the proper method of procedure and to advise us regarding a suitable mixture for these castings.

Gas, whether natural or artificial, is a desirable, clean fuel for melting brass and we recommend its use whenever possible. However, it cannot be employed in the manner outlined. A furnace properly constructed should be installed, together with a blowing unit.

An alloy suitable for castings for these torches, follows: Copper, 88.50 per cent; tin, 6.50 per cent; lead, 2 per cent and zinc, 3 per cent.

Progress in the Manufacture of Steel Castings

An Account of the Gradual Advancement of the Steel Casting Industry—Recent Attempts to Improve Quality of Metal

By Robert P Lamont

EVERY ton of steel produced by present methods may properly be called cast steel, but only a comparatively small percentage of this steel, in its final form, may be correctly described or referred to as steel castings. There seems to be a rather small margin of difference between pouring the molten metal into an ingot mold preparatory to rolling or forging it, and pouring the same metal into a mold in which it takes its final form and shape. Therefore, it does not seem as if it should require any great inventive skill to step from one process to the other. In principle it is a simple matter, but the practical difficulties were great and the development of the cast steel industry was correspondingly slow.

Because of this rather narrow line between the first stage of ordinary steelmaking and what is in a sense the final stage of making steel castings, it is difficult to point out any definite place and date at which it can be said with certainty, "Here is where the making of steel castings began." In the large volume of literature on the early history of steelmaking there are practically no references to steel castings. The expression *cast steel* is frequently used, but it refers in every case to the pouring of the metal into ingot molds.

The probabilities are that the first castings were of simple form, such as could be produced in metal molds, and were no more difficult to make than ingots. As more complicated shapes were attempted, the necessity developed for a different kind of mold. The art, if it may be so called, was no doubt a gradual development, and no single name stands out prominently as the inventor of steel castings as now produced.

Developing the Industry in Europe

However, there seems to be no question but that the credit for making the first steel casting belongs to Germany. In the report of our federal commissioner, William P. Blake, to the Vienna Exposition of 1873, in describing the exhibit of the Bochum Steel Works in Westphalia, this statement is made: "One of the special operations in this works is the casting of steel in molds, after the invention of the technical director of the works, Jacob Mayer." Although the process was not patented in that country, it remained for 10 years the exclusive property of the company and of those works in France and England which had obtained the rights to manufacture. The report continues: "Another specialty of these works is the manufacture of cast steel bells. We have not space to detail all of the advantages and virtues of cast steel bells." Their manufacture dates from 1851. As early as 1855, at the Paris Exposition, the bells of the company attracted general attention. The surprise of the inspectors at this new steel product, indeed the doubt as to the possibility of working steel in this way, was so great that they desired an inquiry to be made to ascertain whether these bells were really steel, as was represented, or whether they were made of cast iron. The result of the inquiry was the bestowal of the great gold medal by the jury of the Exposition upon the following grounds: "The exhibited bells are characterized by perfection of performance, and a very clear unmixed tone, which is as clear as that of the ordinary

*Presented at the annual meeting of the American Iron and Steel institute. The author is president of the American Steel Foundries, Chicago.

FIG. 1—CAST STEEL HOUSING FOR MILL OF LUKENS STEEL CO.—WEIGHT 24,045 POUNDS

bronze bells." As a consequence the jury came to the conclusion that the Bochum company, by its method of molding and pouring steel, had not only superseded bronze as the material for bells but had given a new direction to the manufacture of large forged and rolled pieces of machinery. The bells were cheap, costing about one-half as much as bronze bells; they were heavy, and since 1855 their manufacture had greatly and rapidly increased. In 1858 a test proved "that it is impossible with human power to crack one of these steel bells with heavy sledge hammers."

Made Steel in Crucibles

The steel in these early castings was melted in crucibles and cast in metal molds. Jacob Mayer is the only individual name mentioned in this reference to the early history of steel castings, but it is not clear from the report whether the technical director in 1873 was the originator of the industry which apparently started in 1851.

Immediately after the Paris Exposition of 1867 the Terre Noire Works of France, began a series of experiments to produce a metal to meet the requirements for projectiles for navy guns. They used a Siemens-Martin furnace, and the subject was gone into thoroughly from a metallurgical standpoint, probably for the first time. A number of irons were tried with the addition of a certain amount of steel scrap before casting. The results showed that the addition of scrap improved the iron, but the variations in the breaking points of the steel were found to correspond with the amounts of silicon it contained. If the addition of steel scrap was pushed beyond a certain limit, blow-holes began to appear. Experiments showed that projectiles made of this steel would not stand up in test. It was determined that to obtain steel without blow-holes, a proportion of 11 to 12 per cent of pig containing 3.5 per cent to 4.0 per cent of silicon should be added. This gave a hard metal and proved unsatisfactory. The metal was pasty, ran badly, and did not stand forging well. It was found necessary to add a certain amount of manganese in the initial bath, which made the slag sufficiently fluid to separate from the metal. It was of greatest importance to keep the oxidation as low as possible, and the process finally resolved itself to the employment of manganese and silicon in definite proportions and at regulated times. The metal was tapped directly into the molds, there being two tap holes, side by side, running into one spout fitted with two nozzles.

About 1870, this company was producing all sorts of industrial castings, such as cast steel car wheels, frogs, roll-pinions, etc. It was not until 1875 that the Terre Noire company produced a cast steel shell which would go unharmed through armor plate. By 1879 these works were producing 200 tons of steel castings per month, about half of which consisted of projectiles for the French government. The elastic limit of the steel was about 16 to 28 tons per square inch, with an elongation of from 2½ to 15 per cent.

At the Paris Exposition of 1878 the Hadfield Steel Foundry Co. of England, exhibited double spur wheels, railway crossings, wheels, pulleys, hydraulic cylinders, etc.

In the United States a few attempts were made during the civil war to produce small field pieces of cast steel. A number of steel works are reported to have made steel castings for their own use during this period. The best information indicates that the first steel castings produced in this country, which were of value commercially, were made in July, 1867, by the Wm. Butcher Steel works, which afterwards became the Midvale Steel works. These were crossing frogs for the Philadephia & Reading railway and were made of crucible steel. This was before the adoption of silicon for solidifying steel, and the castings were honeycombed in all parts, except the wearing surfaces, which were solid and very smooth. The excessive sponginess of these castings, however, prevented their general use, although W. F. Durfee, who was superintendent in 1871, stated that they made quite a number of steel castings for reversible frogs, which weighed from 250 to 900 pounds.

In 1870 William Hainsworth of Pittsburgh, erected a small furnace having two crucibles, and made castings for the cutting parts of agricultural implements. He kept on experimenting until his capital was nearly exhausted, but in March, 1871, he incorporated a company and erected a plant at Pittsburgh. This was known as the Pittsburgh Steel Casting Co., and was one of the first steel foundries in the country. In making his molds Mr. Hainsworth used ground coke mixed with ground plumbago crucibles, German clay, which was tempered with glue water. On this mixture he took out a patent.

Open-Hearth for Cast Steel

In the latter part of 1874 Mr. Hainsworth had an open-hearth furnace constructed, which in 1875 was used in making steel castings. These, I believe, were the first steel castings from an open-hearth furnace in this country.

On April 28, 1876, the Midvale Steel Co. made two hammer dies of open-hearth cast steel, and the next month made a hammer head weighing 2535 pounds. The appearance of these castings was against them, as the surfaces were imperfect and the sand adhered to them in large quantities. There was also considerable trouble caused from piping and cracking.

The first use of the bessemer process for making steel castings is said to have been made by Mr. Hainsworth in 1881. One writer during this period states that castings of plain section, weighing 100 pounds, sold as high as 20 to 25 cents per pound. However, from 1867 to 1880 the output of steel castings was very small.

First Steel Casting Shops

A number of other plants now commenced producing steel castings. One of the concerns which achieved unusual success was Mackintosh, Hemphill & Co., Pittsburgh, better known as the Old Fort Pitt Foundry. It began the manufacture of steel castings by the Terre Noire process in 1881 and 1882.

In 1882 the Solid Steel Casting Co. was founded by J. K. Bole, S. T. Wellman, T. R. Morgan Sr. and S. J. Williams. The plant was erected at Alliance, O., and the first steel was made in 3½-ton open-hearth furnace. This is now the Alliance plant of the American Steel Foundries.

Another plant built about 1882 was the Standard Steel Castings Co., Thurlow, Pa. This firm first made castings by the crucible process, but installed an open-hearth furnace in September, 1884. They were unusually successful with large work, furnishing many steel castings for government vessels. This is now the Thurlow plant of the American Steel Foundries, and still turns out many castings for battleships, cruisers, and other large vessels. At the present time it has just finished all of the castings for superdreadnaughts PENNSYLVANIA and ARIZONA, and has on hand unfilled orders for castings for nine battleships and cruisers.

About this time, that is 1882, the business began to develop more rapidly, and in 1885 there were quite a number of successful plants in operation, among which may be mentioned: Solid Steel Casting Co., Alliance, O.; I. G. Johnston & Co., Spuyten Duyvil, N. Y.; S. G. Flagg & Co., Philadelphia; Chester Steel Castings Co., Chester, Pa.; Pittsburgh Steel Casting Co., Pittsburgh; Mackintosh, Hemphill & Co., Pittsburgh; Cowing Steel Castings Co., Cleveland; Eureka Steel Casting Co., Chester, Pa., and the Standard Steel Casting Co., Chester, Pa.

Much difficulty was experienced with molding sand in these early days, and it was claimed that the Midvale people, for instance, lost money regularly on steel castings for years while trying one mixture after another. At first a molding mixture of ground brick, ground pots and fire clay was used. The next step was to leave the ground pots out of the mixture, and to wash the mold

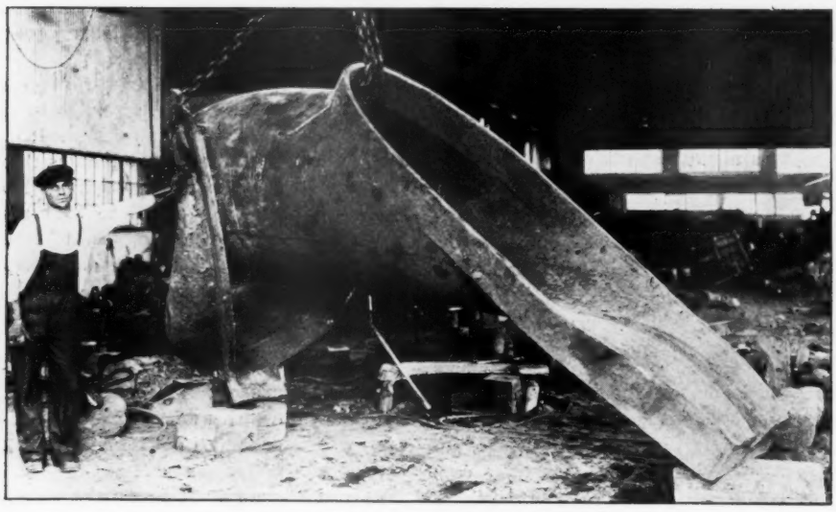


FIG. 2—CAST STEEL HAWSE PIPE FOR BATTLESHIP MISSISSIPPI—WEIGHT 12,930 POUNDS

with finely-ground clay fire brick. This made a marked improvement in the general appearance of the castings. However, the mold became hard, and intricate castings could not be made on account of cracks. Next, a mixture of sand and flour was tried, but there was a tendency for the flour to burn out. By 1887 a suitable mixture of sand and molasses had been obtained. George Cowing, of Cleveland, is credited with first making a mold for steel castings composed of nearly pure silica, glue water and molasses. At this time all molds were baked in ovens, but efforts were being made towards perfecting a process to allow the casting of small shapes in green sand. This was probably first attempted successfully by steel founders in the St. Louis district, which had now become quite prominent in the steel casting industry. In general, castings produced about this time were anything but satisfactory. In large castings, particularly, the earlier molds would burn onto the metal, or the metal would penetrate the molds in a spongy mass, requiring a great deal of labor and expense for chipping. Reference is made by writers in the 80's to pinions weighing 13,000 pounds requiring two weeks to clean, and on which there was a piecework price of $2.00 per tooth. It must be remembered that at this time there were no pneumatic hammers. These first castings were hard, brittle, and not homogeneous. They were so full of blow-holes that one writer defined the ordinary steel casting as a rough chunk composed of about equal parts of steel and holes.

The shrinkage problem was more difficult than with gray iron castings, and it took years of patient effort to overcome the many difficulties involved.

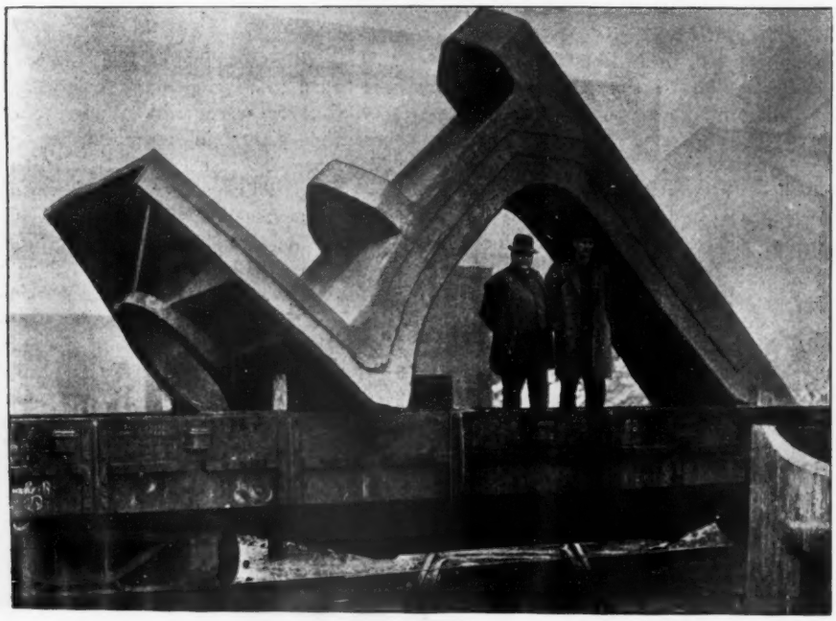


FIG. 3—CAST STEEL STERN POST FOR BATTLESHIP CALIFORNIA—WEIGHT 44,540 POUNDS

Although the field for steel castings kept widening, they were not giving universal satisfaction. Their appearance was against them. Very few of the foundries had their own laboratories. In going over the history of the business during this period, 1880 to 1890, one gets the impression that the castings were pushed on the market before the art was fully developed, and with the result that steel castings fell into a certain disfavor which seemed to retard the progress of the industry for several years.

Our own government was one of the first to experiment with and make extensive use of steel castings in this country, especially for battleships. Between 1880 and 1890 the English founders were successfully turning out stern frames, rudders and stem pieces. Our own people apparently had not acquired the same skill, for in his report for 1890 Engineer-in-chief Melville, of the navy department, stated: "I am obliged to report we are having a most discouraging experience with steel castings." He further said that when the first new vessels were being built, the steel founders claimed that they could cast anything in steel that could be cast in iron, but that there was now (1890) a wide diversity among steel founders as to what shapes were practicable for casting in steel.

In 1887 congress passed an act calling for the manufacture of three cast steel, 6-inch, breech-loading rifles, to be made by the crucible, open-hearth or Bessemer processes, and to weigh approximately 11,000 pounds each. Only two were supplied, one of bessemer steel and one of open-hearth steel. In the tests the Bessemer gun failed at the second round. The open-hearth steel rifle was cast by the American Steel Casting Co., Thurlow, Pa., and was not submitted to any mechanical treatment after casting. Although it stood the statutory test of 10 rounds under service charge, there was a slight increase in the diameter of the barrel after the tests and the government rejected the gun. Failure of these tests caused a good deal of comment at the time and discouraged further efforts along this line.

Steel Casting for Railroads

Although at the present time a very large percentage of all steel castings produced in the country are used by the railroads, it is interesting to note that as late as 1885 very few were being used on cars or locomotives. At a meeting in Washington this year, the Railway Master Mechanics' Association devoted some time to a discussion of their use. A number of the members were using steel castings for cross-heads only, and on a few roads driving boxes, link hangers, eccentrics and rocker arms, in addition, were being made of cast steel.

The Pennsylvania railroad specifications in 1888 for steel castings required a tensile strength of 70,000 pounds and an elongation of 15 per cent in two inches.

At the Chicago Exposition in 1893 there were exhibited by Krupp some steel castings which at that time were considered very remarkable, among them being a cast steel frame for a Pennsylvania railroad locomotive. At a meeting of the American Society of Mechanical Engineers at the time, doubt was expressed as to whether any American steel foundry could make such a casting. A contrary opinion was expressed to the effect that possibly three or four steel foundries in this country could make such a casting but that probably several castings would be lost before a successful one could be produced. Stimulated possibly by this exhibit and by the growing demand, American manufacturers soon demonstrated their ability to make these frames, for five years later they were being generally used. These first frames were light and of simple design, as compared with those now made every day as a mater of ordinary routine. At the present time frames are not infrequently 34 feet long, and weigh up to 14,000 pounds. The percentage of loss in a good foundry does not exceed four.

Development During Recent Years

During the past 20 years the development of the steel casting industry has been steady and rapid, although, of course, the production has had ups and down following general business conditions. Beginning with the nominal production of 1684 tons in 1883, by 1897 the production had increased to approximately 100,000 tons. Today there are about 200 steel foundries in the country, with a total rated capacity of approximately 2,000,000 tons, though the actual production given for last year was 1,286,509 tons. The production curve for steel castings for the past 20 years plotted alongside of one showing, for instance, the ingot production of the country shows a considerably more rapid rate of increase for steel castings.

While the product cannot even yet be said to be perfect, a great deal of careful, painstaking, intelligent study has been given to overcoming the difficulties in the processes, and it can at least be said that steel castings, to a large extent, have lived down the somewhat uncertain reputation earned during the first development period.

In this connection I think it not out of place to refer to the disaster to the center span of the great Quebec bridge on Sept. 11, last. Practically all of the early newspaper accounts, and even a good many of the technical journals which were published before a thorough investigation was made, gave as the cause of the accident the failure of a

FIG. 4—LARGE STEEL CASTING INVOLVING DIFFICULTIES IN MOLDING

steel casting. One of the railway journals went so far as to say, "It was the well-known treachery of a steel casting." As many who read the first accounts may not have followed the matter further, I would like to read a short extract from an editorial in the *Engineering News* of Oct. 5, written after there had been ample time for a complete investigation:

The rocker casting that broke was too weak by its very design. It was unsafe. So also were its three brother rockers. Because one of the four broke it has been called defective—it was rendered weaker than the others by some internal condition. But calling this one rocker defective does not mean that the other three were safe and adequate.

The stress analysis presented on another page brings out the plain hard fact that the rockers at the time of failure were under very high stress. Figuring on neither the most favorable nor the most unfavorable basis of calculation, it is certain that the stress was higher than would be considered safe even in the very dependable rolled steel members of bridges. It was higher than the stress which the engineers of the Quebec bridge permitted in the rolled steel bars of the great chains by which the span was being lifted, although these had been tested so thoroughly that their large factor of safety was amply established.

Moreover, the engineers knowingly allowed higher stress in the rocker castings than in the chains, although (by test) the chains could not fail until 60,000-pound stress was passed, while the ultimate strength of the rockers was entirely problematical. They allowed the high stress to be applied as a tensile stress to a thin projecting edge of a casting, where, if anywhere, a crack might have its origin. Even worse, the thin edge carried its highest stress at the root of a re-entrant right-angle corner of the casting, where the fillet had been notched to make a carefully fitted seat for a centering plate. This edge, also, was the top of the casting, where im-

FIG. 5—MUSHROOM ANCHORS FOR GOVERNMENT LIGHTHOUSE SERVICE —WEIGHT 5000 POUNDS

purities often have a tendency to gather.

It was a clear case of a badly designed casting.

Of the approximately 2,000,000 tons capacity of steel castings in the country today about 52 per cent is for basic and 48 per cent acid steel. Almost 90 per cent is produced in open-hearth furnaces, 8 per cent in the converter and the balance by the crucible and electric processes. We have no accurate figures showing a division of tonnage as between dry and green sand molds, but the figures are probably not far from 60 per cent green sand and 40 per cent dry sand.

A comparatively recent important development in the industry was the introduction of the electric furnace. Steel melted in the electric furnace can be brought to almost any state of purity desired, and a very high temperature can be secured. The electric furnace will produce steel of as good quality and at lower cost than the crucible, assuming, of course, a reasonable price for current and sufficient demand to take the output of the furnace.

It is not necessary here to describe the difference between the acid and Bessemer methods, but it might be well to say that practically all machine castings, castings requiring any machine finish, are made of acid steel, while all miscellaneous car castings, such as bolsters, side frames, centerplates, couplers, etc., which do not require machining, are made of basic steel and in green sand molds.

Acid steel castings, particularly, if made in dry sand molds, present, as a rule, a better external surface and are freer from pinholes and surface defects. When you get below the surface, however, a test of basic steel will show just as good physical properties as the acid steel. The production of acid as compared with basic steel is less complicated from a mechanical standpoint, and is rather more generally susceptible of control in the matter of soundness or freedom from blow-holes. The fact that it takes about an hour, as a rule, to pour an average heat into steel castings, means, of course, that the slag is in contact with the top of the metal in the ladle just this length of time; and the basic slag takes up the silicon from the steel and in return gives up substantial amounts of phosphorus, with the result that the last metal to leave the ladle is inclined to be wild, resulting in porous castings, and sometimes a rather high percentage of phosphorus. This difficulty is not met in the acid steel.

Difference in Cost

There is, I think, a somewhat mistaken impression as to the difference in cost between acid and basic steels. At the present time low phosphorus pig, which is used in the acid process, is selling for about $80 per ton, and low phosphorus scrap $40 per ton, while basic pig is, say $42 at Pittsburgh, and heavy melting scrap about $32. Taking into account simply the difference between these figures, apparently the acid steel would be very much more expensive than the basic. However, when account is taken of the fact that a much smaller percentage of pig is used in an acid heat than in a basic heat—that the melting time is considerably shorter, the melting loss being about 2.5 per cent of the metals charged, and the life of the furnace substantially longer—the difference in cost is not great. At the present time, taking all factors into account, I should say that in the Chicago territory, for instance, the difference in cost is not more than $2 per ton, in favor of the basic steel.

Dry Sand and Green Sand Molds

The so-called dry sand mold is made of a mixture of silica sand and fire clay, modified in some cases with small percentages of rosin, dextrine or flour. After the mold is finished it is dried in an oven, which is kept at a temperature of about 500 degrees Fahr. for from six hours to six days, depending upon the volume of sand to be dried. This drying process, of course, ties up a large amount of flask equipment, requires a great deal of fuel and extra handling, and adds at least $1 per ton to the cost of the castings over the green sand method. In the case of large, rangy castings, such as stems, stern posts and rudders for battleships, the molds have to be rammed, then split into sections, which are dried separately, and finally fitted together on the dry floor before the casting is poured. Under ordinary conditions such a mold is in process of construction 10 days or two weeks before it is ready for the metal. In the case of the steamship PRINZESS IRENE, which went aground on the shore of Long Island, April 6, 1911, the steamship company was anxious, of course, to get the vessel back into the service as promptly as possible, and offered a liberal bonus for the completion of a new sectional stern frame in less time than was usually taken for such a casting. The record in this case was 11 days, and the bonus earned was almost equal to the price of the casting.

Green sand is composed of silica sand and silicious fire clay, in the proportion of about one of clay to 10 of sand, all thoroughly bonded in a heavy sand mill. These molds can be filled immediately after they are prepared, in fact, the sooner the better, for if they are allowed to stand unusually long, the cores take up considerable moisture, and in dry weather the sand mixture tends to lose its bond and disintegrate. The development of this green sand method of making a casting gave a great impetus to the business, on account both of reduced cost and of smaller investment required in plant and equipment. The problem of getting a proper molding mixture was the great difficulty confronting the early manufacturers of steel castings.

On account of the length of time it takes to pour an ordinary ladle of steel into castings, and because also many castings have thin sections, it is necessary to have a metal temperature at the time the heat is tapped of about 2800 degrees Fahr. The melting point of silica sand is about 3200 degrees Fahr., so that the margin between the temperature of the steel and the melting point of the mold is rather narrow. As a matter of comparison, the pouring temperature of gray iron is from 2200 to 2300 degrees Fahr., and of malleable iron from 2300 to 2400 degrees, which is well below the melting point of the mold, and the sand is not seriously injured; whereas, in a steel foundry the facing sand, so-called, which comes in contact with the hot metal a few times is practically destroyed, and can thereafter be used only for backing. If a good surface is required for castings, care must be taken in every case to see that only new sand is used where it comes in contact with the metal. In green sand work about 1500 pounds of new sand are required per ton of castings, and in dry sand the average is a ton of sand to a ton of castings.

The next great difficulty which confronted the manufacture of steel castings was to avoid shrinkage cracks. The contraction of cast steel is about $\frac{3}{32}$ inch per foot, practically double that of cast iron. To get an idea of what this means, a locomotive frame 34 feet long, for instance, will shrink or contract 6 or 7 inches in length in cooling from a liquid to a solid state, and provision, of course, must be made to allow this contraction to take place. A long, slender section of a casting, with flanges or projections at both ends, will invariably crack, and in extreme cases pull itself apart, unless the holding power of the mold against these flanges or projections is removed in time. It is important in the designing of steel castings to avoid, wherever possible, such a condition as this. It is equally important to avoid a sudden change from a heavy to a light section.

Use of Risers

Another great difficulty with the proper production of steel castings is the avoidance of pipes and shrinkage cavities. This can be done only by the use of risers or shrinkheads of sufficient size and number and properly located. In extreme cases the weight of metal in these risers—which must, of course, be cut off—equals the weight of the casting itself, and the average of net production of

castings probably is not over 65 per cent of the metal charged. In green sand work, where the sections are thin and heavy risers are not used, the yield may, in some cases, run somewhat over 75 per cent. The cost of cutting-off these risers, and the fact that to produce a ton of castings requires from 1½ to 2 tons of metal, is a very large item in the cost of steel castings. Not infrequently these risers are necessarily located on a casting at points extremely difficult to reach with a cutting tool. In the last few years the use of gas cutting torches has greatly facilitated the removal of heavy risers.

Another difficulty which has long been difficult to overcome, the one which perhaps more than any other has been the cause of a good deal of the unfortunate reputation steel castings had in the earlier stages of the development of the business, was porosity — blow-holes so-called. There are many causes for this condition, among the principal of which are improper composition of metal, wet sand, too much carbonaceous material in sand mixture, poorly-ventilated cores, too rapid filling of the mold, improper gating, etc. The truth is, that the proper making of a steel casting calls for the coordination of a good many elements and compositions; if any one is imperfect, the effect is sure to be seen in the casting. And the difficulty is that in the handling of certain of these elements, no rules can be laid down which will satisfactorily guide an inexperienced man. Skill based on long experience is the only apparently sure guide. Of coure, the metal itself, up to the time it reaches the mold, is susceptible of pretty exact manipulation, but for the proper method of molding, and the location of gates and risers, there are apparently no rules that can be laid down.

Need of Annealing

After the casting is all but finished, it must be annealed to relieve possible internal strains due to irregular shrinkage in the casting itself, and the different rates of cooling due to variations of sections, etc. There has been a great deal of difference of opinion on this question of annealing. Some makers have gone so far as to claim that it was not necessary. A paper could be written on this subject alone. Our experience is that annealing is necessary; certainly it is in the direction of safety. The proper annealing temperature depends upon the carbon contents of the casting and ranges from about 1300 to 1500 degrees Fahr. for carbons from 0.20 to 0.90. The only certain method of determining whether a casting has been properly annealed is by a microscopic examination of a test piece broken from the casting. The time taken in bringing the casting up to the proper temperature and the rate of cooling are both important factors in the final result.

The past history of the industry has been about the same as that of most industries. The early experimental and development stage was difficult and unprofitable. In course of time a few successful businesses were developed and made money. After that there was apparently a too rapid expansion of capacity, excessive competition and no profit. Then followed the usual dropping out of the weak and the building-up of the strong companies. During recent years, when general business conditions have been good, I think the industry as a whole has shown a fair margin of profit. Following policies and methods suggested and practiced by this institute, the larger companies have been more inclined to work on a *live and let live* basis. We have been exchanging information as to methods, comparing costs, and undertaking in certain directions to adopt standard designs and specifications, all with the idea that by improving our methods and reducing our costs, we will broaden the field of the industry and make more work for the benefit of all.

Intelligent Use of Nickel-Plating Solutions

By E P Later

IN SPITE of the fact that nickel-plating has been practised for a great many years, and even at the present time is one of the most important and widely used of the various finishing processes, our knowledge regarding the mechanism of the operation is by no means complete and there are many points upon which further investigation is needed. In the early days of the art platers surrounded themselves and their work with a great air of mystery, and the most profound secrecy was observed in regard to the composition of the plating baths; each one had his own formula, and with the amount of doping with all sorts of things that some of those old baths received it is surprising that they produced a deposit at all.

There was almost no knowledge of the effect exerted by each of the various substances employed; in fact, this is one of the points on which our information at the present time is not so complete as might be desired, but in the course of time many of the substances which were added, perhaps more as a matter of habit or custom than anything else, were found to be either useless as far as conferring any beneficial effects was concerned, or even deleterious. Some of the constituents were gradually eliminated and the formulas for plating baths have been more carefully worked out until now there is a strong tendency to make the composition as simple as possible. We cannot go beyond a certain limit in this direction, however, inasmuch as experience has shown that a solution, in order to give the most satisfactory results, must contain various other substances besides nickel salts; therefore a knowledge of the action of different materials is of much importance, not only in producing the best and most efficient bath, but also in helping to correct the defects which arise from time to time and are often very troublesome.

Valuable Laboratory Tests

The results of an investigation of some of these points were reported a short time ago by Dr. Mathers and some of his co-workers, and it is believed that the facts which they have brought to light should be of much interest and help to platers; although the experimental work was carried out on a laboratory scale and all of the conditions might not be identical with those which are found in practice, there is little doubt that the conclusions which were drawn would apply, at least in a broad way, to nickel solutions operated on a commercial scale.

One part of the investigation was concerned with the advantages to be gained by the use of comparatively pure nickel anodes, as compared with the older style anodes containing about 92 per cent of nickel and 6 per cent of iron. For a long time it was thought to be necessary for anodes to contain a fairly large amount of iron to make them dissolve properly, but more recently anodes of higher purity have come into greater favor. These contain about 95 per cent nickel, 2.5 per cent tin, 1 per cent iron and smaller amounts of other impurities and are an improvement over the older type, but there seem to be certain disadvantages inherent to the use of anodes containing more than a very slight amount of impurities, which deserve mention here.

One of these is that unless all of the metal dissolved from the anode is deposited on the cathode the solution continually changes composition. Ordinarily the iron dissolved from the anode is either oxidized by contact with the air

and precipitated out as a sludge, or it is deposited along with the nickel on the work which is being plated. The result is that, compared with the iron, the content of nickel in the bath decreases slightly, but through the removal of the iron in this fashion only a part of it, approximately one-half, can be deposited. Ordinary commercial deposits may contain upwards of 3 per cent iron, when anodes of high iron content are employed, and this exercises a deleterious effect, if only in the way of producing a dark, bluish-colored deposit, which is of course objectionable. Experimental deposits prepared so as to contain a considerable percentage of iron were less smooth than pure nickel deposits, also harder and more difficult to buff. It has further been claimed that nickel coatings containing appreciable amounts of iron tarnish and corrode more easily than purer deposits; this may often be a matter of some importance.

The aim of the plater is to produce as white a deposit as possible; blue or smoky deposits are not in high favor; therefore, if only on this score alone, it would seem that the use of anodes of high purity would be advisable.

The formation of a sludge in the bottom of the plating tank is annoying to say the least and may be the cause of more or less trouble. A deeper tank than would ordinarily be required for the work must be employed to afford a sufficient depth of liquid in order that that the parts may not hang down in the sludge, which would result in a rough, frosted deposit. Further, care must be exercised when putting in or taking out work to avoid stirring up the sludge, thus precluding the possibility of stirring or otherwise agitating the bath, so that a higher current density can be employed with consequent increase in capacity, and it is usually necessary to filter the solution occasionally to clarify it and keep it in good condition.

Cause of Sludge Formation

Sludge formation probably cannot be blamed entirely on the use of impure anodes. Some will form even if anodes of high purity are employed; consequently other means of combatting the trouble have been devised. One of these, putting the anodes in bags, which will retain any insoluble matter, needs no comment, but the addition of ammonium citrate to the bath may be considered briefly. This salt has the property of dissolving both nickel and iron hydroxides and therefore when added to a bath will prevent the formation of sludge entirely. In the investigation under discussion as little as 0.3 per cent was found to be sufficient to keep the solution perfectly clear and free from turbidity, although practical experience on a commercial scale might show the advisability of changing this amount slightly. The effect of suspended foreign matter in producing rough work is too well known to need more than passing mention here, and there is no doubt that any effective measures which may be taken to obviate this condition are generally well worth whatever trouble or expense their application entails.

Addition of Ammonium Citrate

The addition of ammonium citrate to a nickel solution means that all of the iron will be kept in solution, instead of part of it becoming oxidized and precipitating out, and nearly all of it will be deposited with the nickel, in consequence of which the deposit will be darkened considerably.

In connection with the use of pure anodes, the necessity of having some chlorine present in the bath in order to facilitate the solution of the metal was brought out in a rather striking manner by the fact that an anode efficiency of 99.71 per cent and a cathode efficiency 95.67 per cent at 13.9 amperes per square foot were obtained with a certain solution containing 2 per cent of magnesium chloride; while another bath identical in all respects with this, except for the absence of the magnesium chloride, showed an anode efficiency of only 17.5 per cent, while that for the cathode was 60 per cent. Either sodium chloride or nickel chloride may be used as the source of chlorine, although sodium exerts a harmful effect on the deposit and for that reason is a less desirable agent. Anode efficiency of more than 99 per cent was obtained with a single nickel salt bath containing a little less than 2 per cent sodium chloride.

Nickel baths vary rather widely as far as composition is concerned, and a good deal has been written on this subject, extolling the merits or pointing out the defects of some of the formulas commonly used, and the holders of opposing views have often defended them with considerable warmth. For example, the controversy regarding the respective merits of single nickel salts, as compared with the nickel-ammonium or double salt, attracted rather more than the usual amount of interest not so very long ago, and perhaps this is not strange in view of the fact that each has certain points in its favor. The so-called double nickel salt is particularly adapted in some ways for plating, and very good deposits may be obtained from it, but by reason of its rather slight solubility, the concentration of solutions prepared from it is comparatively low. This in turn means that the permissible current density is also low. The investigators found that a good deposit could be obtained up to 2.8 amperes per square foot, but with higher densities gas was given off and a *burned* deposit was produced. A number of different salts, magnesium sulphate, magnesium chloride, potassium chloride, and so on, were added in varying amounts, but they only reduced the current which could be used without burning, and it developed that boric acid was the only substance which served to prevent this at higher densities. Thus, with 5 per cent of boric acid in the bath, only slight burning was observed at a density of about 18 amperes per square foot.

The effect of increasing the nickel content of double salt baths, by the addition of various amounts of the single nickel salt, nickel sulphate, as might be expected, was to increase the current density at which good deposits could be obtained, and allow of a decrease in boric acid content. Thus the addition of 5.3 per cent of nickel sulphate with 1 per cent of boric acid made it possible to produce good deposits at 18 amperes per square foot; with 8 per cent of nickel sulphate considerably less boric acid, 0.3 per cent, was needed to prevent burning.

Baths containing both the single and double salts have found a rather wide use, and it was learned that one made up from 7 per cent of each of these, 1 per cent boric acid and about 0.2 per cent of ammonium citrate, worked satisfactorily at a current density of nearly 15 amperes per square foot.

Effect of Different Salts

Some interesting observations also were made on the effect of different salts on the deposit produced by this solution. It was found, for example, that an increase in boric acid content tended to brighten the deposit, but apparently did not affect it in other ways. Increasing the acidity of a nickel bath up to a certain point usually results in a brighter deposit. Just what the function of boric acid is may be open to question, but it is always used in nickel baths and aids very materially in the production of a good deposit; from 1 to 3 per cent is a satisfactory amount to use.

The question as to how boric acid functions and whether it may be replaced by other acids has been the subject of some investigation, and apparently there is a difference of opinion on this point. Mathers concluded that boric acid cannot be replaced by citric, acetic or benzoic acids, as far as the production of satisfactory results are concerned. It is the usual practice to keep the acidity of a bath below the point where it will affect the indicator known as Congo red, and it may be that the amount of these acids which were, or could be, added under the conditions was too slight to affect the working of the bath. It may also be possible that boric acid may exert some other effect other than producing

a certain amount of acidity which these other acids are not capable of causing.

Magnesium salts have been found to produce a marked whitening effect on the deposit from baths containing nickel ammonium sulphate and even large amounts, 10 per cent or so, do not appear to do any harm. Potassium chloride, sodium chloride and sodium sulphate, on the other hand, when added in amounts up to 11 per cent, darken the deposit, the degree of darkening corresponding roughly to the amount of salt present.

Effect of Ammonium

It is peculiar, in a way, that nickel-ammonium sulphate apparently contains about the maximum allowable amount of ammonia consistent with good deposits, at least when anodes containing a considerable percentage of iron are employed, but this seems to be the case, inasmuch as decreasing the proportion of ammonium to nickel, by adding a straight nickel salt brightens the deposit; the darkening effect of sodium salts is likewise decreased at the same time. A nickel bath apparently can stand a small amount of sodium or ammonium, or both, without suffering any appreciable deterioration in the quality of the deposit, but when the sum of these has reached a certain ratio to the quantity of nickel present darkening is observed. The amount of sodium salt required to produce this effect depends, at least partly, on the amount of ammonium present; when this is high in proportion to the nickel only a comparatively small amount of a sodium salt will be needed to produce blackening, and on the other hand, when only a small quantity of ammonium is in solution, as compared to the nickel present, considerably more sodium may be added before serious darkening of the deposit takes place. In any case, the darkening effect of sodium is less than that of ammonium, and baths in which anodes containing much iron are used are much more susceptible than those fed from purer anodes, thus indicating that this difference in behavior is due to the iron present in the former.

An increase in the amount of boric acid will tend to lessen the darkening of the deposit by these salts, but the simplest and most logical way of avoiding the trouble would be to eliminate sodium altogether by using magnesium or nickel chloride to supply the chlorine necessary for ready solution of the anodes. If for any reason it is desired to use the double salts it will be advisable to add a certain amount of the single salts to the bath, as this will allow a more concentrated solution to be made, and the reduction in the proportion of ammonium may exert a further effect in the way of whitening the deposit. As a matter of fact, a bath with 4 per cent nickel-ammonium sulphate, 1 per cent boric acid, 0.2 per cent ammonium citrate and from 8 to 16 per cent of nickel sulphate gave the best results of any which were tested; the deposits were brighter after buffing and, as would be expected, the effect of the alkali metals in producing dark deposits was much less. It has the further advantage that the acid content need not be so carefully regulated as in the case with baths made up from the single nickel salts.

While we are considering the composition of nickel baths it may not be out of place to mention some of the work which has been done on the problem of nickeling zinc, inasmuch as it has involved considerable experimenting with solutions of varying composition. Zinc is finding a wide and increasing use in such household articles as cabinets, table covers and similar articles, while die-castings, which are made from zinc alloys, are being produced in large quantities and it is often necessary or desirable to give these parts a nickel finish. Little difficulty is encountered in coating the ordinary metals, other than zinc, with nickel, but zinc has given a good deal of trouble in this respect and much has been said concerning the causes and remedy therefor.

If a piece of zinc is immersed in a nickel bath, unlike any of the other metals, it quickly becomes covered with a black deposit which prevents the coating subsequently plated on from adhering, with the result that peeling-off soon takes place. This peculiar behavior is due to the fact that zinc is electro-positive to nickel and therefore tends to displace the latter from its solutions, going into solution itself as the nickel plates out in metallic, but very finely divided, form; the same sort of a phenomenon is observed when a piece of iron is placed in an acid copper bath. Ordinarily the electro-positive nature of zinc is a distinct advantage and is put to a good use in protecting iron parts from corrosion by coating them with zinc, as in galvanizing, but in this particular instance it is objectionable, and various means have been employed in the attempt to overcome it.

Coat Zinc with Copper

One simple way out of the difficulty is to coat the zinc parts with copper before nickeling; satisfactory results may thus be obtained, but it involves so much extra handling that the cost of finishing is increased unduly, so that this scheme is not without its disadvantages.

Hammond, another investigator, has recently made a study of this problem, and the facts which he has brought to light are worthy of note.

Plating solutions have been made up containing different salts which were added for the purpose of making the zinc less electro-positive to the solution. It has been found, however, that very little or nothing can be, or at least has been, done along this line, and all of such solutions which were examined produced blackening of any zinc parts which were immersed in them. Sodium citrate was found to lessen the rate at which this deposition of finely divided nickel takes place and so, to this extent, exerts a beneficial effect.

It is well known, however, that heat increases or promotes chemical action; so it would be expected that the temperature of the nickel bath would influence considerably the rate of deposition of nickel on the zinc, and direct tests have shown that this is the case. For instance, at 0 degrees Cent. immersion of zinc strips in a nickel bath for 45 minutes produced only a slight coloration; the intensity of the action increased steadily with increasing temperature, 20 seconds immersion at 90 degrees Cent. sufficing to produce a blue-black color on the zinc. Working solutions hot is not uncommon, and there is much to be said in favor of it, but it is apparent that nickel baths must not be used too warm when zinc is to be plated.

Increasing Chemical Action

Another way of increasing or promoting chemical action is to increase the concentration or amount of the reacting substances present, in consequence of which it would readily be inferred that the more salt a nickel bath contains the more rapidly would the nickel be deposited on the zinc; this is likewise the case. This explains, too, why all of the solutions which have been proposed for the direct nickeling of zinc are low in metal content and consequently can be employed only at relatively low current densities.

In order to determine the best conditions for the deposition of nickel on zinc, a large number of solutions of different strengths and compositions was tested; the content of nickel sulphate varied from somewhat over 5 ounces per gallon to saturation. Some of the baths contained only nickel sulphate, while to others a certain proportion of nickel chloride was added; still other baths were made up from mixtures of the two salts acidified with various acids. The current density likewise varied widely, ranging from about 1.8 amperes per square foot to 140 amperes per square foot.

The result of this work was to show that nickel can be plated directly on zinc from a bath of almost any concentration, which at the same time is slightly acid in reaction and contains chlorine in the form of nickel chloride, to give good anode corrosion. One of the secrets of the successful operation of

baths which are employed for nickeling zinc is the use of the proper current density, which is somewhat higher than that required with ordinary metals, particularly at the beginning. In other words, it is necessary to *strike* the parts, so that a thin deposit of nickel can be quickly given, which then will prevent any action between the zinc and the solution, with the resultant formation of the black, pulverulent deposit. The initial current density which must be used varies somewhat with the concentration of the nickel in the bath, but it has been found that the alkali salts of certain organic acids, citrates, malates and tartrates make it possible to use lower densities at the beginning of the operation.

A bath of the following composition has been recommended for plating zinc directly: Nickel sulphate, 32 ounces; nickel chloride, 2 ounces; boric acid, 4 ounces; sodium citrate, 23 ounces, and water, one gallon. It is claimed that this bath works satisfactorily at current densities ranging from about 4.6 amperes per square foot to 65 amperes per square foot. It is advisable to use only pure electrolytic anodes with this bath.

Beehive Coke Production

The production of beehive coke in 1916 was the greatest ever recorded in the United States, and the average value per ton was higher than in any previous year. The official figures for 1916, published by the United States geological survey, show that 35,464,224 tons of beehive coke, valued at $95,468,127, were produced last year. The output in 1916 represented an increase over 1915 of 7,955,969 tons, or 29 per cent, in quantity, and $38,522,584, or nearly 68 per cent, in value. The average value per ton of the coal used in making beehive coke in 1916 was $1.26, an increase of 21 cents, or 20 per cent, and the average value of the coke was $2.69, an increase of 62 cents, or 30 per cent.

The number of active beehive ovens in 1916 was 65,605, as against 48,985 in 1915, an increase of 16,620. The number of idle ovens was 25,976, as against 44,125 in 1915. Abandoned ovens numbered 2265, of which nearly 1800 were in Pennsylvania and West Virginia. No new establishment and but 104 new beehive ovens at old works were reported to be under construction at the end of 1916, a low record compared with recent years, especially in view of the high prices and steady demand for coke throughout the year. The coke producers evidently recognize the fact that the day of the beehive oven is passing, and that after the present abnormal condition is over most coke will be made in by-product ovens.

The Sand Mixing Machine Co., 52 Vanderbilt avenue, New York, recently received orders for auto sand cutters from the following concerns: Wehr Steel Co. and the Falk Co., Milwaukee, Akron Steel Casting Co., Akron, O.; United States Malleable Iron Co., Toledo, O.; George V. Cresson & Co., Philadelphia, Interstate Foundry Co. and Ferro Foundry & Machine Co., Cleveland.

Early Types of American Heating Stoves

By W J Keep

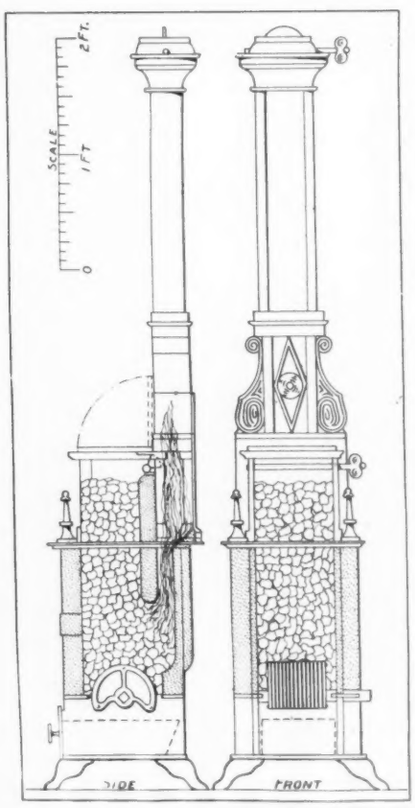


FIG. 1—SIDE AND FRONT SECTIONS OF THE BASE BURNER PATENTED BY DR. NOTT IN 1828

PROBABLY the first stove made in this country is illustrated in Spark's edition of the works of Dr. Benjamin Franklin (vol. 6, page 34) and was called the Pennsylvania fireplace. This was the first Franklin stove, having been made at Warwick Furnace, Pa., about 1742.

The first patent for a stove granted in this country was issued to Robert Heterick on June 11, 1793, for "A Cast Iron Stove". The second stove patent was issued May 4, 1802, to Henry Abbott, for casting "Close Stoves". Records are not available containing descriptions of these stoves nor the addresses of the inventors. The third patent for a stove was granted to Allan Pollock, of Boston, on June 11, 1807. The same stove was patented in England and the sketch of this Pollock stove, shown in Fig. 2, was taken from an engraving in the "Repertory of Arts", second series, vol. 12, page 170.

Anthracite coal was discovered in surface outcroppings at Mauch Chunk, Pa., in 1793, but as it was found to be almost impossible to burn it, less than 365 tons were mined before 1820. About that time the Lehigh Coal Mine Co. sent a small quantity of this American coal to Dr. Nott, president of Union College, Schenectady, N. Y., who in-

FIG. 2—DR. NOTT'S BASE BURNING STOVE IN THE POSSESSION OF W. J. KEEP

vented a wood-burning stove. He was requested to build a stove in which this coal could be burned. After experimenting for five years he applied for several patents for "The Evolution of Heat" from this coal, in 1826 and 1827. On March 26, 1828, he applied for patents on the stove illustrated in Figs. 1 and 2.

The coal was broken in small pieces and filled the brick-lined chamber. It was burned on a *saracenic grate*, as Dr. Nott termed it, which, when rolled over, formed a basket into which fell the clinkers and slate. When the grate was rolled back again the clinkers and slate fell out into an ash pan, leaving a bright fire in the grate. The coal burned at the base of the body of the charge and the products of combustion passed through a small brick-lined flue into an iron radiator above. These tall radiators were popular for many years. The castings for this stove were ¼-inch thick in the ornamented parts. This stove was presented to the writer in 1866 and constituted a part of the exhibit of the Michigan Stove Co. at the World's Fair in Chicago, in 1893.

The patent for which Dr. Nott applied in 1828 was not issued until Sept. 17, 1832. On May 30, 1832, Jordon L. Mott, of New York City, was granted a patent for a base burning stove which embodied many of the principles of the modern base burner. The stove designed by Jordan L. Mott and patented in 1832, is shown in Fig. 4. This stove had a self-feeding magazine. The surface of the burning coal, after it left the magazine, sloped to the side of the firepot. A large combustion chamber was provided above the burning coal. In 1849 a patent was granted to Thomas Walker, in England, in which the combustion chamber and sloping coal extended all around a cylindrical magazine.

Mr. Mott always contended that he was the first to develop the modern base burner, which undoubtedly is true, but Dr. Nott, four years earlier burned coal at the base of a chamber filled with coal. Prior to 1834, castings for stoves were made at a blast furnace near Philadelphia, the iron as it flowed from the furnace having been poured into molds. At about that date, however, Jordon L. Mott, in New York; Joel Rathbone, in Albany, and James Wager, in Troy, built foundries for the exclusive manufacture of stoves, the iron having been melted in cupolas. The foregoing notes are taken from the manuscript entitled "History of American Stoves", by W. J. Keep.

A 12-page booklet has been issued by the William Powell Co., Cincinnati, which illustrates and describes the automatic injector which it manufactures. A table of sizes and a price list also are included. The method of connecting the injector is illustrated and suggestions for its installation are given.

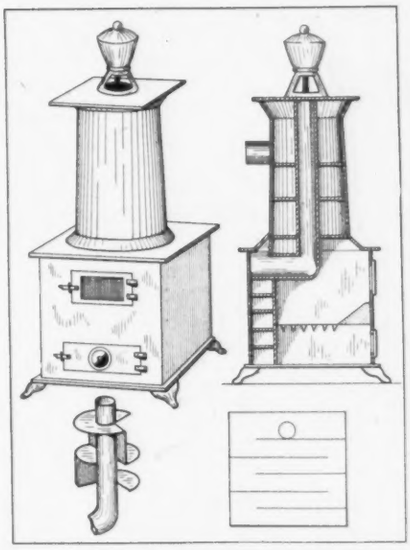


FIG. 3—STOVE PATENTED BY ALLAN POLLOCK IN 1807

Production of Semisteel Shells

By David McLain

The article published on page 253 of the July issue of THE FOUNDRY entitled, "What the War Has in Store for the Foundry Trade", is very interesting, particularly the recommendation that a commission be sent to France to investigate the process of making cast shells. However, the writer does not believe that it is necessary to send a commission to France for this purpose.

The iron ore in France is high in phosphorus and the pig iron made therefrom contains 2 per cent and more of this element. High phosphorus pig iron melted in the cupola with steel scrap is unfit for semisteel. Owing to the high phosphorus in the pig iron, the basic process of making steel in France is compulsory, both in open-hearth and converter practice and, therefore, is highly developed. Assuming that one-third, by weight, of liquid converter metal is added to the cupola iron, which may carry 0.02 per cent of phosphorus in the ladle of cupola metal of 50 steel and 50 iron, then the phosphorus in the final mixture will be approximately 0.60 per cent, which is within fair limits for light sections.

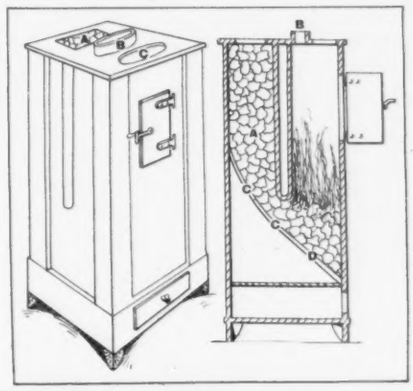


FIG. 4—BASE BURNING STOVE PATENTED BY JORDON L. MOTT IN 1832

However, it may be possible that "the bessemer converter metal, low in phosphorus" referred to, is not pig metal, but blown liquid metal, and this feat can be duplicated anywhere in the south, by installing basic converters and using high phosphorus pig iron. Again it may be possible that the French are using hematite pig, which is now selling at $35 per ton in England and is similar to our low phosphorus pig iron, selling at $80 to $100 in this country. However, if the French are able to import pig iron from England, which I am inclined to doubt, why should they add one-third converted metal to the cupola metal? However, 40 per cent of hematite pig iron, 30 per cent of French pig iron and 30 per cent of steel, melted in the cupola will produce a hotter metal, which is more homogeneous and of lower phosphorus content and can be made at a lower cost.

In Germany, semisteel shells have been made for many years, and in December, 1914, in an address delivered before the Detroit Foundrymen's association the writer discussed the employment of semisteel for projectiles and shells. A few of my auditors did not agree with me, yet I maintained that semisteel would be used extensively before the war was in progress many months.

Semisteel shells have been made in this country for some time and we will be glad to place our services at the disposal of our munitions experts to prove to them that semisteel is a satisfactory metal for this purpose.

In the government specifications covering projectiles, the metal is referred to as "cast iron of 30,000 pounds tensile strength or over", but we know of no cast iron test bars that have met these requirements and, therefore, from 30 to 40 per cent of steel scrap is added to the mixture with the result that a tensile strength of 32,000 pounds per square inch and more is obtained. For this reason we term this metal semisteel.

In the place of babbitt metals one inventor proposes to use mixtures of metallic sulphides in widely varying proportions. He considers that the sulphides of copper, lead, tin and antimony make good babbitt substitutes. Metallic sodium is used to improve their casting properties.

THE FOUNDRY

A monthly journal devoted to all branches of the foundry trade

Published by

The Penton Publishing Co.

Penton Building, CLEVELAND

BRANCH OFFICES

BIRMINGHAM, ENG.....Prince's Chambers
CHICAGO.....1521 Lytton Bldg.
CINCINNATI.....205 Lincoln Inn Court
NEW YORK.....508 West Street Bldg.
PHILADELPHIA.....1316 Land Title Bldg.
PITTSBURGH.....2148-49 Oliver Bldg.
WASHINGTON, D. C.....708 Metropolitan Bank Bldg.

SUBSCRIPTION

United States and Mexico.....$1.00 a year
Canada.....$1.50 a year
Great Britain and other Foreign Countries Eight Shillings
Single Copies.....15 cents
Copies published three months or more previous to date of current issue, 25 cents each.

ADVERTISING

All communications relating to advertising copy, discontinuances, etc., must be received on the 10th of the month preceding date of publication.

ENTERED AT THE POST OFFICE AT CLEVELAND AS SECOND CLASS MATTER

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War—The Industrial Crucible

IT IS generally conceded that much of the progress made in the development of an industry results from the dissemination of knowledge and experience among manufacturers and engineers. Up to within a few years ago the interchange of ideas was largely confined to the borders of each nation, and there was a noticeable tendency in many instances for the leading powers to closely guard their inventions and developments for local benefit. Largely on account of this practice, the engineering talent of each nation soon evidenced decided proficiency in specialized lines of endeavor. In Germany an enviable reputation for efficiency and execution of detail was attained. England, though slow to grasp the principles of systematized management, acquired a unique faculty for thoroughly investigating the intricacies of metallurgy. American engineers developed the ability to organize industry for producing large quantities of standardized articles.

The war already has shown signs of altering this standard of industrial development. Martial necessity is enlisting the aid of American ingenuity in solving the problems of France, England and Russia, and the engineers of these European nations are lending their experience to manufacturers in the United States. Although the present exchange of knowledge is chiefly restricted to matters pertaining to military problems, there is nothing to indicate that the welcome innovation will not spread to other lines of pursuit. Perhaps we are warranted in anticipating the time when the spread of technical information will be international.

Trade Outlook

ALTHOUGH the tendency to attain higher levels was not as marked in July as in the preceding months, the price of pig iron continues its march toward the $75 figure, which many forecasters have set for the end of the present year. The railroad situation continues to hold the price of foundry coke at the high mark established several months ago. Bessemer iron is quoted at $57 to $58, and basic at $52 to $55, valley. No. 2 foundry pig iron is listed in the leading trade centers as follows: Pittsburgh, $55.95; Chicago, $55; Cleveland, $55 to $56; Buffalo, $52 to $54; Birmingham, $47 to $50; and Philadelphia, $52 to $53.50. Connellsville foundry coke sells at $13.50 to $14.

James Brice once said: "There is no influence in any community more potent and powerful for the accomplishment of good, than that of business men unselfishly banded together for the purpose of promoting the general welfare of the entire citizenship." In the foundry field no organization comes nearer to wielding this influence for good than the American Foundrymen's association. At no time in history has there been a greater need for this influence than the present. Therefore, foundrymen who have the welfare of the industry at heart will encourage, support and attend the annual meeting at Boston.

Death of P. L. Simpson

Peter Liston Simpson, manager of the National Engineering Co., died July 11, at his home in Chicago. Mr. Simpson was born in Boness, Scotland, and served his apprenticeship in Bathgate Foundry, Bathgate, Scotland. He moved to Toronto, Canada, in 1870, where he married Janet L. Teasdale of Airdrie, Scotland. After working in several foundries in Toronto, he moved to Cleveland, where he finally became owner of a gray iron foundry. While he was superintendent of Youngslove Massey Co. in Cleveland, he made an engine cylinder which is thought to have been the first steel casting produced west of the Ohio river. In 1881 he moved to Minneapolis, where he was foundry superintendent for the North Star Iron Works. Later he embarked in the clay-working machinery business, inventing a dry press brick machine, which became widely and favorably known. He also designed and built a gear-molding machine which attracted considerable attention among foundrymen. In 1889 he moved to Chicago, where he lived until his death, except for two years, 1903 and 1904, when he was located in Willoughby, O. In recent years he designed a foundry mixer, a core reducer and a screen separator, all of which bear the name of the inventor and are manufactured and sold by the National Engineering Co., a company which Mr. Simpson organized and developed. Mr. Simpson was a member of the Chicago Foundrymen's club, American Foundrymen's association, and was reputed an expert in foundry management. He leaves his wife, a daughter and two sons, one of whom, H. S. Simpson, has taken charge of the National Engineering Co.

Personals

George M. Deems has been appointed manager of the Elmwood Castings Co., Cincinnati.

Oliver C. Brace has resigned as sales manager of the Farrell-Cheek Steel Foundry Co., Sandusky, O., to devote his time to the Sandusky Nut Co., of which he is president.

F. A. Beebe, formerly director of foundries of Sears-Roebuck & Co., Chicago, has been appointed foundry superintendent of the Haskell & Barker Car Co., Michigan City, Ind.

W. H. Quirk has been appointed manager of the electrical supply house of the Western Electric Co., Cincinnati. W. L. Sioussat will succeed Mr. Quirk as store manager at Cleveland.

G. W. Guilderman, who resigned as superintendent of the foundry of the Advance-Rumley Thresher Co., La Porte, Ind., several years ago, has returned and resumed his former duties.

G. C. Jones has resigned as metallurgical engineer of the Whiting Foundry Equipment Co., Harvey, Ill., to accept a position with the Huntington Steel Foundry Co., Huntington, Ind.

C. C. Peterson, formerly affiliated with the Bridgeport Malleable Iron Co., and the Rhode Island Malleable Iron Co., has been appointed works manager of the Standard Malleable Iron Co., Muskegon, Mich.

R. A. Bull has resigned as vice president and general manager of the

PETER LISTON SIMPSON

Chicago Steel Foundry Co., Chicago, to accept the position of vice president and general manager of the Duquesne Steel Foundry Co., Coraopolis, Pa.

J. A. Flood, formerly connected with the Venango Mfg. Co., Franklin, Pa., now is general manager of the Producers Supply Co., that city, which recently completed a new gray iron foundry, having a daily capacity of 25 tons.

L. P. Orr, Cleveland representative of the Allis-Chalmers Mfg. Co., Milwaukee, assumed the position of sales manager of the Cleveland Electric Motor Co., on May 1. Mr. Orr has had a wide experience in the manufacture and sale of electrical equipment.

S. Carroll, for many years affiliated with the National Transit Co., Oil City, Pa., in the capacity of foundry superintendent, and later with the Taylor-Wilson Mfg. Co., McKees Rocks, Pa., has been appointed foundry superintendent of George B. Limbert & Co., East Chicago, Ill.

W. R. Day, general manager of the Hart-Parr Co., Charles City, Iowa., has been elected vice president to succeed A. E. Ellis, resigned. Donald D. Davis has been elected secretary to fill the vacancy existing by the appointment of C. H. Parr to he position of chief engineer.

Harry H. Barclay, manager of the Beryk Co., Cleveland, manufacturer of foundry vibrators, has been elected president and general manager to succeed Charles H. Olds, resigned. M. W. Barclay was elected vice president, and E. B. Carbaugh, secretary and treasurer, succeeding C. H. Keith, resigned.

M. Cochran Armour has withdrawn from the firm of Rogers, Brown & Co., Cincinnati. For a period of 27 years he was a member of this partnership, having been admitted in 1890. Mr. Armour represented the Rogers, Brown interests in the Chicago district for more than a quarter of a century, and he was widely known as a producer and distributor of pig iron.

Oil For Cores

Through a typographical error in the advertisement of the Werner G. Smith Co., Cleveland, in the July issue of THE FOUNDRY, it was stated that "Linoil binds more acid, stronger cores, ..." The sentence in question should have read, "Linoil binds more sand, makes stronger cores, ...".

The Damascus Bronze Co., Pittsburgh, is building an extension, 60 x 100 feet, to the molding department of its foundry. A smaller building, 20 x 100 feet, is under erection. Additions are being erected under the supervision of Prach & Perrine, Pittsburgh, architects and engineers.

The Ross Power Equipment Co., Merchants Bank building, has been appointed Indianapolis representative of the Lincoln Electric Co., Cleveland, manufacturer of alternating and direct-current motors and generators, electric arc welding plants and automobile battery charging apparatus.

Doughten & Son, 41 South Fifteenth street, Philadelphia, have leased the mica schist and silica rock quarries of the William Penn Silica Works, Conshohocken, Pa. Mining operations will be commenced immediately.

Slag Test for Refractory Brick in Steel Industry

Methods of Determining Effect of Fineness of Slag on Penetration —Drilled-Pocket Method Gives More Uniform Results Than Immersion

By C E Nesbitt and M L Bell

EARLY in the study of the physical properties of refractory material in the iron and steel industry, the necessity for a slag test which would give information as to the relative resistance of refractory brick to various slags and fluxes became apparent. To be of use in specifications it was evident that such a test must be rapid, easily performed, and applicable to any kind of brick or slag, and should as far as possible approach conditions similar to those under which the brick is to be used.

As a basis for a test it was decided to place the brick in contact with a certain slag and apply heat until the slag was thoroughly melted. When cold the amount of penetration was observed. In the preliminary work the piling of the slag on the brick was tried, but the results were negative, as the slag ran off the brick as soon as melted, producing no marked penetration. Kaolin rings were tried in hope of confining the slag, but these failed to accomplish their purpose. Pockets were next cut in the brick by chipping. This proved to be successful in confining the slag but the chipping was too slow and it was difficult to secure uniform cavities. Drilling by means of a press was next resorted to, and uniform pockets as near as the nature of brick material would permit were drilled. The bricks were then heated to testing temperature and a known quantity of slag was placed in the drilled cavities. After the bricks had become cold they were broken through the slag cavity and examined. Visual examination proved of small value, as results could not be accurately compared; hence it was found necessary to devise some means by which the amount of penetration could be measured. This was accomplished by sawing the brick so that one of the sawed faces accurately bisected the center of the original cavity, and the area of slag penetration thus exposed was then measured by means of an ordinary planimeter.

To standardize the method it became necessary to determine whether the fineness of the slag, the time to which the slag was exposed to the brick, and the amount of slag used in the test had any effect upon the amount of penetration.

Determining Effect of Fineness

To determine the effect of fineness of the slag on the amount of penetration, blast furnace and heating furnace slags were selected as representative of the iron and steel industry. Each was ground and separated into two sizes, coarse and fine. The coarse material was that which passed a 40-mesh and remained on a 60-mesh sieve, while the fine was represented by that which passed through a 100-mesh sieve. The slag test was then run in the usual manner on standard hearth and bosh blast furnace brick. The average results were as follows:

	Penetration, square inch.
Blast-furnace Slag—	
40 to 60-mesh	1.54
100-mesh	1.67
Heating-furnace slag—	
40 to 60-mesh	1.77
100-mesh	1.72

From the above results it is apparent that the degree of fineness of the slag does not affect penetration.

To determine whether the time to which the slag was exposed to the brick, and also whether the amount of slag used in the test affected the penetration, a series of slag tests were run, in which the slag was exposed to the brick at testing temperature for two, four and six hours, with the quantity of slag varying from 35 to 140 grams. The result of slag penetration are given in Table I.

In Table I it is shown that the amount of penetration is not increased by keeping the brick in contact with the slag for a longer period than two hours. Preliminary work had shown that one hour would in most cases give complete penetration, so that the adoption of two hours was considered sufficient to guarantee full action of the slag.

It will also be noted that there are two variables, namely, the amount of slag used and the area exposed to slag action. To make the average results comparable these variables must be eliminated. This was accomplished by reducing the area exposed to slag action to a unit figure by dividing the area of the standard cavity (5.94 square inches) into each of the other areas (columns 3, 4 and 5 in Table I). The ratio figures thus obtained were divided into the average slag penetration and the results (slag penetration divided by ratio) made comparable. These figures prove that increasing the amount of slag does not affect the slag penetration, when reduced to a unit of area exposed to slag action. The variation in the results are within checking limits and the difference due to the variation in the bricks themselves.

The question of the advisability of performing a slag test in a drilled pocket as compared to immersing the brick in molten slag was next studied. Bricks from the same shipment were tested, one-half of them by the drilled-

Presented at the annual meeting of the American Society for Testing Materials, held at Atlantic City, June 26 to 29.

Table I

Effect of Fineness on Amount of Penetration

Time of Exposure, hours.	Penetration for—Grams of Slag used, square inch. 35	79	105	140
2	0.49	0.58	....	....
2	0.51	....	0.79	....
2	0.45	....	....	0.79
4	0.51	0.58	....	....
4	0.43	....	0.78	....
4	0.43	....	....	0.83
6	0.46	0.52	....	....
6	0.44	....	0.70	....
6	0.52	....	....	0.89
Average	0.45	0.56	0.76	0.84
Area exposed to slag action, square inch.	5.94	7.97	8.57	9.44
Ratio of exposed area to standard cavity.	1.00	1.34	1.44	1.59
Average slag penetration divided by ratio	0.45	0.42	0.53	0.98

pocket method in the usual way, while the others were placed on edge in a refractory tray or shallow box, in which slag was placed to a depth of 1½ inches. All were heated at a uniform rate of 1350 degrees Cent., and held for one hour. After cooling the bricks were cut at right angles to their length into two or three sections, the cuts being about 1 inch apart. The drilled-pocket samples were cut in the usual way, a second cut being then made at right angles to the first. The areas of slag penetration thus exposed were measured with a planimeter; also, the linear inches of slag contact on the surface of the brick were measured. Heating furnace slag was used in this test. Table II gives the results of these tests.

From the results it is evident that greater uniformity of results is obtained by use of the drilled pocket than by immersion. The drilling of pockets to contain the slag is also preferable to the use of large trays to contain the slag, because of economy of space in the furnace.

The drilled pocket method as at present adopted has several points which recommend it as a standard method. It is very flexible, as cavities, slags, temperature and the amount of slag can be easily changed to correspond to the service conditions under which the bricks are to be used. It is rapid, easily performed, and results are expressed by a definite numerical quantity.

When clay bricks for blast furnace or similar uses are to be tested, blast furnace and heating furnace slags are used. Silica bricks for open-hearth use are tested with open-hearth and heating furnace slags.

Table II

Comparison of Drilled-Pocket and Immersion Methods

		Immersion Method.			Drilled-Pocket Method.		
Sample.	Area No.	Slag penetration, square inch.	Slag contact of brick, linear inch.	Slag penetration per linear inch of contact.	Slag penetration, square inch.	Slag contact of brick, linear inch.	Slag penetration per linear inch of contact.
A	1	5.50	7.0	0.78	1.67	3.5	0.48
	2	1.68	7.0	0.24	1.48	3.5	0.42
	3	2.50	7.0	0.36	....	...	....
B	1	4.96	8.5	0.58	1.10	3.5	0.31
	2	4.82	8.5	0.55	1.06	3.5	0.30
C	1	0.91	10.0	0.09	0.88	3.5	0.25
	2	0.57	10.0	0.10	0.71	3.5	0.20

G. J. McFadden, formerly connected with the Chicago Pneumatic Tool Co., Chicago, now is general manager of the Nagle-Corliss Engine Works, Erie, Pa., manufacturer of gas and steam engines, air compressors and vacuum pumps.

Samuel L. Nicholson, who has been sales manager of the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., since 1909, has been appointed assistant to the vice president of this company.

Herbert A. Johnson has resigned as superintendent of the North & Judd Mfg. Co., New Britain, Conn., to accept the chairmanship of the hardware equipment committee of the council of national defense.

WHAT THE FOUNDRIES ARE DOING

Activities of the Iron, Steel and Brass Shops

The Starr Foundry Co., Covington, Ky., has increased its capital from $20,000 to $40,000.

The Richmond Foundry & Mfg. Co., Richmond, Va., has increased its capital from $100,000 to $400,000.

The Taylor Coupler & Castings Co., Toledo, O., has completed the erection of a foundry building, 60 x 126 feet.

The Fulton Foundry & Machine Co., Cleveland, recently has been organized with $10,000 capital by Harold T. Clark and others.

The American Foundry Co., Elizabeth, N. J., has been incorporated with $125,000 capital by Morris Jigger, Otto Froebel and others.

The Globe Foundry & Mfg. Co., Berkeley, Cal., has been incorporated with $50,000 capital by A. J. Tucker and R. S. and H. R. Elliott.

The Leetsdale Foundry & Mfg. Co., Leetsdale, Pa., has been incorporated with $30,000 capital to engage in the manufacture of gray iron castings.

The National Castings Co., Carlisle, Pa., has been organized with $50,000 capital by Jacob R. Foreman, A. G. Vashoar, R. Morrett and Walter R. Sohn.

The machine shop and foundry of Thomas Carlin's Sons, Pittsburgh, were sold at public auction to the Modern Machinery Exchange and the Manhattan Machinery Exchange, New York, for $120,100.

The Bloomfield Foundry Co., Bloomfield, N. J., manufacturer of brass, aluminum and nickel castings, has completed an extension to its plant, 65 x 125 feet.

The Cotter Brass Foundry Co., Pittsburgh, has been incorporated with $10,000 capital to engage in the operation of a plant for the manufacture of brass castings.

The Rhode Island Foundry & Machine Co., Providence, R. I., has been incorporated with $100,000 capital by Henry S. Chaffee, Dwight R. Bartlett and Samuel Raynor.

The East Chicago Foundry Co., East Chicago, Ind., has been incorporated with $30,000 capital by Harry C. Stuart, Henry S. Evans and P. S. and William F. Graver.

The Chrisman Foundry Co., Westover, W. Va., has been incorporated with $100,000 capital by A. H. McBee, Frank Fox and E. F. Beall, all of Morgantown, W. Va.

The Modern Foundry Co., Cincinnati, is building an addition to its plant, 80 x 200 feet, part of which will be devoted to pattern storage, and in the other section new core ovens will be installed.

The Portage Foundry Co., Akron, O., has been organized with $150,000 capital to engage in the operation of a gray iron foundry. S. W. Harris, W. E. Wilson, G. F. Hobach, C. G. Wise and H. E. Andress are the incorporators.

The Sweetser & Bainbridge Metal Alloy Co., Albany, N. Y., has been incorporated with $10,000 capital to engage in the manufacture of metal alloys. The incorporators are S. P. Sweetser, E. F. Bainbridge and H. E. Batcheller.

Benjamin E. Jarvis, Newark, N. J., who has operated a large jobbing pattern shop, has incorporated under the name of Benjamin E. Jarvis, Inc., with a capital of $50,000. In addition to Mr. Jarvis, the incorporators include J. T. Clark and L. C. Lotz.

The American Tank & Valve Co. has removed from Indianapolis to its new plant at Fairmont, W. Va. The works consist of a gray iron and brass foundry, 60 x 160 feet, and a machine shop, 90 x 180 feet. Provisions have been made for an extension to the machine shop, 90 x 200 feet.

The Columbian Brass Foundry, 30 Church street, New York, and the Columbian Bronze Corp., Freeport, L. I., have been consolidated under the name of the latter corporation with a capital of $450,000. The Columbian Bronze Corp. operates a plant in Freeport for the manufacture of brass fittings for motor boats and similar specialties.

The Champion Foundry & Machine Co., Chicago, which recently changed its name

from the Champion Foundry Machine Co., has established a gray iron foundry at Aurora, Ill. The plant is equipped with two cupolas and recently was placed in operation. J. T. Magnuson is president and H. O. Magnuson is secretary and treasurer.

The Lewisburg Stove Co. is the firm name of the corporation which has acquired the plant of the Lewisburg Foundry Co., Lewisburg, Tenn. The patterns of cook stoves and heaters, cast and steel ranges, as well as the range machinery, will be sold. This company will manufacture heaters. W. T. Archer is president and C. C. Stoll is secretary and treasurer.

The Brady Foundry Co. has completed three buildings of its new plant, which is one of the largest foundries in Chicago, producing general heavy gray iron castings. The new buildings are 140 x 300, 90 x 220 and 90 x 200 feet, respectively. Although some heats are being taken off at present, the new foundry will not be operated to capacity until the middle of August.

New Construction

C. A. Goldsmith, Newark, N. J., will erect an addition to his foundry.

The Hoods. Mfg. Co., Seattle, Wash., will erect a foundry, 70 x 100 feet.

The Lima Steel Casting Co., Lima, O., will erect an addition to its plant, 50 x 200 feet.

The Belding Foundry Co., Belding, Mich., is building extensive additions to its plant.

The Bedford Foundry & Machine Co., Bedford, Ind., will build an addition, 50 x 80 feet.

The Bristol Brass Co., Bristol, Conn., is building an addition to its plant, 50 x 120 feet.

W. N. Neiman and L. K. Saul, Hamburg, Pa., will build a foundry addition, 50 x 200 feet.

Beatty Bros., Ltd., Fergus, Ont., Canada, contemplate the erection of a malleable iron foundry.

The Lunkenheimer Co., Cincinnati, contemplates the erection of additions to its brass foundry.

The Howard Stove Co., Beaver Falls, Pa., will build an extension to its foundry at a cost of $12,000.

The Glamorgan Pipe & Foundry Co., Lynchburg, Va., will erect an extension to its plant, 40 x 80 feet.

The Dayton Malleable Iron Co., Dayton, O., is building an addition to its plant at Ironton, O., 110 x 160 feet.

The Harrison Steel Castings Co. is commencing the erection of a steel castings plant at Murphysboro, Ill.

The plant of the General Foundry & Mfg. Co., Youngstown, O., recently destroyed by fire, will be rebuilt.

The Eagle Brass Foundry, Seattle, Wash., will erect a foundry, 90 x 105 feet, and a pattern shop, 25 x 29 feet.

The Marshall Castings Co., Marshall, Mich., of which M. Campbell is manager, will erect a foundry at a cost of $25,000.

The Bell City Mfg. Co., Racine, Wis., manufacturer of agricultural implements, will erect a foundry addition, 50 x 120 feet.

The General Electric Co., Schenectady, N. Y., is erecting a foundry building, 80 x 340 feet, four stories high, at East Boston, Mass.

The Gray Foundry, Inc., Poultney, Vt., manufacturer of gray iron castings, recently completed a 60-foot addition to its shop.

The Monighan Foundry Co., Chicago, will build an addition to its plant, 92 x 96 feet. A. P. Webber, 10 South LaSalle street, is architect.

The Killian-Strait Tractor Co., Appleton, Wis., will build a foundry, 50 x 75 feet. This company manufactures gas and oil tractors.

A vocational school will be built by the board of education, Newark, N. J., at a cost of $206,700, which will include a foundry and pattern shop.

The Hamilton Foundry & Machine Co., Hamilton, O., contemplates the erection of an addition to its shop at a cost of approximately $5000.

The Bunting Brass & Bronze Co., Toledo, O., manufacturer of brass and bronze castings, will build an addition to its plant at a cost of approximately $14,000.

The Lake Torpedo Boat Co., Bridgeport, Conn., has awarded contracts for the erection of two foundry buildings, respectively 80 x 100 feet and 20 x 30 feet.

S. Birkenstein & Sons, Chicago, manufacturers of metal alloys, contemplate the erection of a warehouse on a site recently purchased on Hawthorne avenue.

The Mayer Bros. Co., Mankato, Minn., is building an extension to its foundry, 36 x 116 feet. The machine shop also is being increased in size by an addition, 40 x 80 feet.

A steel casting plant to be equipped with electric furnaces will be added to the truck division of the General Motors Co., Pontiac, Mich. The foundry was designed and the construction is being supervised by H. H. Allen, General Motors Co., Detroit.

At the League Island navy yard, Philadelphia, the casting producing capacity will be increased by the erection of a foundry, 180 x 648 feet, at an estimated cost of $532,968.

The Flint Foundry Co., Flint, Mich., which specializes in the manufacture of automobile castings, contemplates the erection of a 50-ton casting shop. F. L. Carpenter is manager.

The Worcester Foundry Co., Worcester, Mass., will erect an addition to its plant, 52 x 198 feet. The Mill Engineering & Construction Co., Waterbury, Conn., has the contract for the erection of the building.

The Independent Foundry Co., West Allis, Wis., recently incorporated, will build a gray iron shop, 85 x 100 feet. The company was organized by several foremen and molders of gray iron foundries in the Milwaukee district.

The Glover Machine Works, Atlanta, Ga., will install an electric melting and refining furnace, to be furnished by the John A. Crowley Co., Detroit. The foundry building, which already has been erected, will be commanded by a 40-foot crane of 15 tons capacity.

The Hesse-Martin Iron Works, Portland, Ore., will erect a foundry, 80 x 100 feet, and a machine shop of the same size. In addition blacksmith and structural shops also will constitute the plant. A specialty will be made of auxiliary machinery for ships, including winches, anchors, steering engines and gears, propellors, etc.

NEW TRADE PUBLICATIONS

COMPRESSORS AND VACUUM PUMPS.—The Ingersoll-Rand Co., New York, in a 32-page bulletin, illustrates and describes compressors and vacuum pumps for the extraction of gasoline from natural gas. Another bulletin is devoted to rock drills, which contains a number of field views illustrating their use.

FOUNDRY AND STEEL WORKS EQUIPMENT.—A 60-page catalog, issued by the Biehl Iron Works, Inc., Reading, Pa., illustrates and describes the extensive line of coal and ore trucks and buckets of various types manufactured by this company. Many types of industrial cars are also shown, as well as skip hoists for blast furnace work. For foundry work a large core oven car is illustrated, as well as flat top trucks, charging barrows, etc.

PLATERS' EQUIPMENT AND SUPPLIES.—An exceedingly comprehensive catalog containing 260 pages has been issued by the Canadian Hanson & Van Winkle Co., Ltd., Toronto, Ont., which is devoted to electro-plating and polishing supplies, including nickel, chemicals, lacquers, dynamos, polishers' and buffers' supplies, grinding machinery, etc. This catalog will prove of value to all operators of plating rooms. A smaller catalog containing 104 pages also has been issued by this company which contains many valuable suggestions for equipping electro-plating plants.

BORONIC METAL ALLOYS.—A 16-page pamphlet has been issued by the American Boron Products Co., Inc., Reading, Pa., which describes boronic copper and boronic metal alloys. These boronic products are deoxidizers for nonferrous and ferrous metals. Boronic copper consists of electrolytic copper impregnated with boronic gases, occluded by the copper. The copper thus treated becomes a flux, and when the gas of boronic copper is liberated in the re-melt it serves the purpose of deoxidizing, cleansing, solidifying and alloying. It is claimed that the gases in their efforts to cleanse the metals from oxides cause a stirring or mixing of the entire metallic mass, creating a molecular migration and thereby effecting an alloy or mixtures, absolutely homogeneous and uniform; 23 boronic specifics are made for alloying and deoxidizing different mixtures, which include boronic aluminum, boronic nickel, boronic copper, etc.

CRANES.—An exceedingly comprehensive 80-page catalog devoted to its extensive line of cranes has been issued by the Whiting Foundry Equipment Co., Harvey, Ill. This company has had more than 25 years' experience in building and operating cranes, and their conveying appliances are offered to the trade for all classes of service, from the simple 1-ton handpower bridge to the heavy electric crane for handling locomotives. In addition to the numerous illustrations of the various types of cranes built, a large number of service views are shown of cranes in operation in railroad shops, foundries, stone quarries, yard service, power plants, freight yards, steel works, cement plants, electric plants, etc. The types of cranes illustrated include 3-motor electric travelers, 2-motor electric crane trolley, 4-motor travelers, gantry cranes, handpower and motor-driven transfer cranes, handpower traveling cranes, single and double I-beam handpower cranes, hand and motor operated hoist travelers, cage and floor pendent travelers, air hoist hand traveler, jib cranes, pillar cranes, work-car cranes, locomotive sand truck cranes, etc.